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THE

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Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

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PROCEEDINGS

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SESSION OF 1934-35
(Vol. XIX, Part I)

SOME UNREPORTED AND RARE FISHES FOR THE COAST OF NOVA SCOTIA.*

V. D. VLADYKOV.

Atlantic Biological Station, St. Andrews, N. B.

(Received April 8, 1935).

ABSTRACT.

This paper is concerned with the occurrence, during recent years, of twenty-two marine fishes, rarely found in Nova Scotian waters. The forms previously not reported from this area are as follows: *Anchoviella epsetus, Caranx hippos, Chaetodon ocellatus, Epinephalus morio, Mugil cephalus, Nansenia groenlandica, Naucrates ductor, Pneumatophorus colias, Remora remora,* and *Sphyrna zygaena.* Practically all the fishes mentioned in this paper are southern forms, which stray to the Nova Scotian coast only when the temperature of the water is high. The number of marine and anadromous fishes, which has been reported from the coast of this province, now amounts to about 150 species.

The fish-fauna of the Nova Scotian region is not very well known, although several papers have appeared dealing with fishes from this area.

The first attempt to give a list of the Nova Scotian fishes was made by Knight[1], who listed 42 species of marine and anadromous fishes. However, his paper is rather a compilation of Perley's data[2]. A more complete list was published by Jones[3], who mentioned 92 species occurring in the area under consideration. Huntsman[4] mentioned 54 species, which were found along the Nova Scotian coast of the Bay of Fundy. Bigelow and Welsh[5], in their account of the Gulf of Maine, also indicated the presence of about 100 species, which have been reported from the Nova Scotian waters.

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[1] Knight, T. F. *"Descriptive catalogue of the fishes of Nova Scotia."* 34 pp. Halifax. **1866**.

[2] Perley, M. H. *"Descriptive catalogue (in part) of the fishes of New Brunswick and Nova Scotia."* Sec. Edit. 50 pp. Fredericton. **1852.**

[3] Jones, J. M. *Proc. Trans. N. S. Inst. Nat. Sci.*, **5**, pt. 1, 87-97. (1882).

[4] Huntsman, A. G. *Cont. Canad. Biol.* **3**, 49-72. (1922).

* This paper is published with permission of the Biological Board of Canada.

In addition to the above papers, there is further information compiled by Piers in several notes published in the Annual Reports of the Provincial Museum (Halifax) and in different articles. The most interesting of these was published in 1903[6], where he described the capture of a Burrfish (*Chilomycterus schoepfi*), 75 mm. long, off Sambro, near Halifax. Recently Leim[7] listed the occurrence of seven southern forms, three from Halifax harbour and four from the Liverpool district.

The present author had the opportunity to secure additional information on the occurrence of twenty-two new and rare fishes in the Nova Scotian area.

The following descriptions are based on personal examinations of the specimens, sent either to the author by different persons for identification, or procured, through the kindness of Dr. A. H. Leim, from the museum of the Fisheries Experimental Station in Halifax. The latter specimens will be indicated by (F.E.S.). The author had also the opportunity to examine specimens from the Provincial Museum in Halifax, through the kindness of Mr. Harry Piers, Curator of the Museum.

The fishes which were not previously reported from Nova Scotian waters are marked with asterisk (*). The dimensions of the fishes throughout the entire paper refer to the total lengths of specimens (the lengths of the caudal fin included).

LIST OF SPECIES

1. Lanternfish, *Aethoprora effulgens* Goode and Bean 1895 (F.E.S.). One specimen, 65 mm. in length, was procured from a cod stomach on the Western Banks on February 1,

---

[5] Bigelow, H. B. and Welsh, W. W. *Bull. U. S. Bur. Fish.* **40**, pt. 1, 567 pp. (1925).

[6] Piers, H. *Proc. Trans. N. S. Inst. Sci.*, **10**, 110-111, (1903).

[7] Leim, A. H. *Proc. Trans. N. S. Inst. Sci.*, **17**, pt. 4, p. xlvi, (1930).

1930. Another specimen was also secured from the stomach of a cod caught on Browns Bank many years ago.[8]

*2. Striped anchovy, *Anchoviella epsetus* (Bonnaterre) 1788 (F.E.S.). Five specimens, ranging from 54 to 59 mm. in length, were caught in a small seine, by Mr. C. Darrach (Fisheries Exp. Station) in Bedford Basin (Roaches Cove) on September 29, 1931. This species was reported for the first time from the Gulf of Maine by Kendall[9] on October 8, 1930, when several specimens were caught near the mouth of Presumpscot River near Portland.

3. Spotted catfish or Leopardfish, *Anarchichas minor* (Olafsen) 1774. A female specimen 123 cm. long was caught on November 5, 1934 by the steam-trawler *Rayon d'Or* (Capt. H. S. Hansen) on the northwestern part of the Quereau Bank (about Lat. 44° 35′N., Long. 59° 55′W.) in 55 fathoms of water.

Many years ago, Bean[10] reported the capture of two fish off Banquereau (Lat. 44° 30′N., Long. 57° 10′W., 250 fths.; Lat. 43° 52′N., Long. 59°09′W., 200 fths.) in rather deep water. More recently Cornish[11] stated that occasional specimens of the Leopardfish were taken by fishermen of Canso (N. S.) during 1901 and 1902, but did not indicate exactly where they were captured.

This species is northern in origin, being quite common around Greenland, Iceland and the Norwegian coasts[12].

4. Triggerfish, *Balistes carolinensis* Gmelin 1788 (F.E.S.). One specimen, 355 mm. in length, was sent for identification by the Fishery Officer A. P. Fitzgerald, Queensport, N. S., on September 5, 1932. Bigelow and Welsh (*loc. cit.*, p. 294) recorded the capture of this fish on Banquereau Bank. The Halifax Museum possesses a specimen caught in Halifax Harbour on August 25, 1910.

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[8] Goode, G. B. and Bean, T. H. "*Oceanic Ichthyology.*" Spec. Bull. no. 2, U. S. Nat. Mus., Washington. **1895**, 553 pp.

[9] Kendal, W. C. "*Remarks on additions to the marine fauna of the coast of Maine*". Bull. Boston Soc. Nat. Hist., no. 58, 9-11, **1931.**

[10] Bean, T. H. *Proc. U. S. Nat. Mus.*, **3**, 82. (1881).

[11] Cornish, G. A. *Cont. Canad. Biol.*, 1902-1905. p. 88. (1907).

[12] Knipovich, N. M. *Trans. Inst. for Scient. Exploration of the North*, **27**, 94. Moscow. (1926).

*5. Crevalle or Yellow mackerel, *Caranx hippos* (Linnaeus) 1766. Three young specimens, ranging from 46 to 49 mm. in length, were caught in the summer of 1933 in Musquodoboit Harbour, N. S. This is a southern fish found from tropical America to Cape Cod, although very rare in the Gulf of Maine.

6. Hardtail, *Caranx crysos* (Mitchill) 1815. Two specimens were examined. One (F.E.S.) 185 mm. long was captured in a weir at Pubnico, N. S. on September 1, 1930, and forwarded by the Fishery Officer G. D'Entremont (Middle W. Pubnico, N. S.). Another larger fish (305 mm.) was caught on September 30, 1934 in mackerel nets by Mr. F. J. Darrach at Herring Cove. Jones (*loc cit.*) stated that this species was not uncommon in Nova Scotian waters at that time.

*7. Common butterfly fish, *Chaetodon ocellatus* Bloch 1787. A young specimen, about 31 mm. in length, was caught, together with three young specimens of *Caranx hippos* mentioned already, in Musquodoboit Harbour, during the summer of 1933. *C. ocellatus* is a typical reef species, common in the West Indies, sometimes straying to Massachusetts[13].

8. Black swallower, *Chiasmodon niger* Johnson 1863. A specimen 167 mm. long was captured on September 23, 1932 with a dip net by Capt. E. C. Mack (Lunenburg, N. S.) south of Browns Bank (Lat. 39° 10′N. Long. 69° 40′ W.). This specimen, floating on the surface, displayed an extended stomach. After splitting the stomach, there was found a specimen of *Nansenia groenlandica*, 245 mm. in length. Deep-water fishes, such as *C. niger*, are occasionally found at the surface. Thus Goode and Bean (*loc. cit.*, p. 292) mentioned that in June 1880 a specimen of the Black swallower was found floating on the surface on Le Have Bank.

*9. Red grouper, *Epinephelus morio* (Cuvier and Valenciennes) 1828 (F.E.S.). Two young specimens, about 30 mm. in length, were taken by Mr. C. Darrach with a small seine in Eastern Passage, Halifax Harbour on October 12, 1928.

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[13] Breder, C. M. "*Field book of marine fishes of the Atlantic coast, from Labrador to Texas*", p. 217. New York. **1929.**

In the same haul was taken a specimen of the Surmullet (*Mullus auratus*), already mentioned by Leim (*loc cit.*). *E. morio* is found from Virginia to Rio de Janeiro, but young individuals may stray northwards to Massachusetts (Breder, *loc. cit.*, p. 162).

10. Trumpetfish, *Fistularia serrata* Cuvier 1817 (F.E.S.). One specimen, 488 mm. in length, including the caudal filament (or 293 mm. without the filament), was procured on September 18, 1931 by Mr. E. B. Robertson, Port Mouton, N. S. Jones (*loc cit.*) mentioned the capture of a specimen of the same species, 880 mm. long, in September 1863 at Portuguese Cove, Halifax Harbour. He indicated also the occurrence of *F. tabaccaria* in the inshore Nova Scotian waters during the summer months.

11. Long-finned Tuna or Albacore, *Germo alalunga* (Gmelin) 1788. The Halifax Museum possesses one specimen, (no. 5146), 122 cm. long, taken on September 8, 1922, with a halibut trawl, off Devil's Island, near the Halifax Harbour. Goode and Bean[14] mentioned the capture of a specimen on Banquereau Bank in the summer of 1878.

12. Seahorse, *Hippocampus sp?* A female specimen, about 82 mm. long, was caught on September 18, 1934 by Mr. V. Slaunwhite of Terrance Bay, N. S., three miles south of Mars Head. Knight (*loc. cit.*) recorded previously the finding of the seahorse in Nova Scotian waters, but he called them by the scientific name *H. brevirostris*. In reality this name is applicable only to a European form. Jones (*loc. cit.*) referred to *H. antiquorum*, also a European form, as being occasionally found during the summer months in the Nova Scotian area. Bigelow and Welsh (*loc. cit.*, p. 178) stated that *H. hudsonius* was found sometimes as far north as Nova Scotia.

The specimen from Terrance Bay differs from *H. hudsonius* and rather approaches to the Pacific form, *H. ingens*. The absence of comparative material does not permit a proper identification of the specimen in question at present.

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[14] Goode, G. B. and Bean, T. B. *Bull. Essex Inst.*, **11**, 1-38. (1879).

13. Opach or Moonfish, *Lampris regius* (Bonnaterre) 1788. A large specimen (137 cm.) was caught with a line trawl in spring of 1932 on Browns Bank by Capt. W. Murphy of Yarmouth. Jones (*loc. cit.*) stated that a specimen was taken at Sable Island during the late fifties (1856?). Goode and Bean (1895, p. 223) recorded a capture of another specimen of this rare fish, which was taken off Le Have Bank.

*14. Common mullet, *Mugil cephalus* Linnaeus 1758 (F. E. S.). A young specimen, 77 mm. in length, was taken together with *Anchoviella epsetus* in a small seine in Bedford Basin, on September 29, 1931. The Common mullet is very rare in the Gulf of Maine, being rather southern in distribution.

* 15. Large-eyed argentine, *Nansenia groenlandica* (Reinhardt) 1841. A female specimen, 245 mm. in length, was taken from the stomach of *Chiasmodon niger,* on September 23, 1932 (for details see description of the latter species). About a century ago Reinhardt[15] obtained a specimen (approximately 80 mm. in length) from Greenland. More recently Schmidt[16] procured a few specimens of this rare fish off the European coast.

*16. Pilotfish, *Nauctrates ductor* (Linnaeus) 1758. Three specimens were examined. One, 404 mm. in length, was caught on Western Banks during August of 1932. Another was captured by Capt. F. Tidman, skipper of the steamtrawler *Viernoe,* also on Western Banks during the first part of August, 1934. It was a male specimen, 420 mm. in length. A female specimen of the same length (420 mm.) was taken, on October 18, 1934, by Capt. Allen Mosher of the schooner *Radio 1,* with a line trawl, using mackerel bait, on Sambro Bank. The Pilotfish is cosmopolitan in all warm seas, straying occasionally north to Maine in the Western Atlantic.

17. Barrelfish, *Palinurichthys perciformis* (Mitchill) 1818. A male specimen (F. E. S.) 242 mm. long was caught on September 6, 1927 by Mr. F. J. Darrach (Herring Cove) in

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[15] Reinhardt, J. C. H. *Vidensk.-Selsk. Naturv. Ath. Afhandl.*, 8, p. lxxiv-lxxv. Kjöbenhavn. (1841).

[16] Schmidt, Joh. *Rept. Danish Oceanog. Exp. 1908-10 Medit. Adjac. Seas.* 4, II. Biol. 1-40. Copenhagen. (1918).

Halifax Harbour, one and one half miles south of the inner automatic bouy. Another specimen of the same sex, 315 mm. in length, was captured on October 26, 1934 from the wharf of the National Fish Co. in Halifax by Mr. Martin Bouchi with hook and line, using haddock fillet as bait.

Bigelow and Welsh (*loc. cit.*, p. 244) considered this species rather common along the outer coast of Nova Scotia, but very rare within the Gulf of Maine. On the other hand, the information which we have been able to obtain leads to the conclusion that Barrelfish is rare in the area under survey.

*18. Chub mackerel, *Pneumatophorus colias* (Gmelin) 1788. Several specimens were examined. One (F. E. S.) 310 mm. in length, was caught on September 12, 1931 at Herring Cove. Three specimens slightly smaller were taken by Mr. G. G. Harnish in a mackerel trap during the latter part of August, 1933 in Hubbards Cove, St. Margaret Bay. According to information from local fishermen, this species is found in small numbers, practically every year. Schmitt[17] credited this fish with irregular appearance around Anticosti, in the Gulf of St. Lawrence. The Chub mackerel was not previously reported from the Nova Scotian waters.

*19. Remora or Sucker, *Remora remora* (Linnaeus) 1758. Two specimens were examined. One specimen, 171 mm. in length, was caught by Mr. G. B. Nickerson (Clark's Harbour, N. S.) ten miles off Cape Sable on June 1, 1933. A female specimen, 220 mm. in length, was removed from a male Blue shark (*Prionace glauca*), 281 cm. long, which was taken on September 9, 1934 by the steam trawler *Viernoe* (Capt. F. Tidman) on the western side of Sable Island (Lat. 44° 10′ N. Long. 60° 45′ W). The finding of this suckerfish together with *Echeneis naucratus*, already referred to by Leim (*loc. cit.*) increased the number of the Remora species, reported in Nova Scotian waters, to two.

20. Common bonito, *Sarda sarda* (Bloch) 1793 (F. E. S.). Two specimens were examined, one 340 mm. long (locality not known). Another specimen, 10 mm. longer was caught

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[17] Schmitt, J. "*Monographie de l'isle de Anticosti.*" 285. Paris. (1904).

off Middle W. Pubnico on September 17, 1930. Jones (*loc. cit.*) mentioned the capture of a young specimen at the mouth of Halifax Harbour.

*21. Hammerhead shark, *Sphyrna zygaena* (Linnaeus) 1758 (F. E. S.). A young male, 520 mm. in length, was caught on September 13, 1932 by Mr. John Dempsey (Herring Cove) in mackerel nets off Herring Cove. This fish is rather common southward from Cape Cod.

22. Moonfish, *Vomer setapinnis* (Mitchill) 1815. Several specimens were examined. Two young fish, 40 mm. long, were captured on September 21, 1929 in Port Mouton Bay, near Liverpool, N. S. Three slightly larger specimens of equal size (58 mm.) were caught by children with their hands in Eastern Passage, and given to the author by Mr. J. P. Henneberry, Fishery Officer (Halifax). Leim (*loc. cit.*) mentioned the occurrence of the same fish in the Liverpool district in the fall of 1928.

From the foregoing descriptions, it is evident that all the forms (with the exception of *Anarhichas minor*) are southern fishes, which stray to the Nova Scotian area only when the temperature of the water is high. Therefore, they are found along the coast of this province, as a rule, only in the late summer or early fall, and particularly during the month of September, when the temperature of the water is usually the highest of the year.

In conclusion, it may be stated that the number of marine and anadromous fishes known to occur along the Nova Scotian coast amounts to about 150 species.

THE HALO COMPLEX OF MARCH 4TH, 1935. AT ST. ANDREWS, N. B.

H. B. HACHEY.

Atlantic Biological Station, St. Andrews, N. B.

(Received May 3, 1935).

ABSTRACT.

A halo complex occurred at St. Andrews, N. B., on March 4, 1935. In addition to the usual halos of 22° and 46°, the parhelia of 22°, and the circumzenithal arc, an upper contact arc, inverted in type, of the 22° halo was observed.

Although parhelia (sun dogs) are not uncommon, a halo complex is a rare phenomenon on the Canadian Atlantic coast. The writer, with the assistance of his associates at the Atlantic Biological Station, made certain notes on a halo complex observed at St. Andrews, N. B., on March 4, 1935. The phenomenon occurred about 4:50 P.M., A.S.T., and lasted "in parte" and "in toto" for about twenty minutes. The outstanding features are noted in Fig. I where aa′ represents

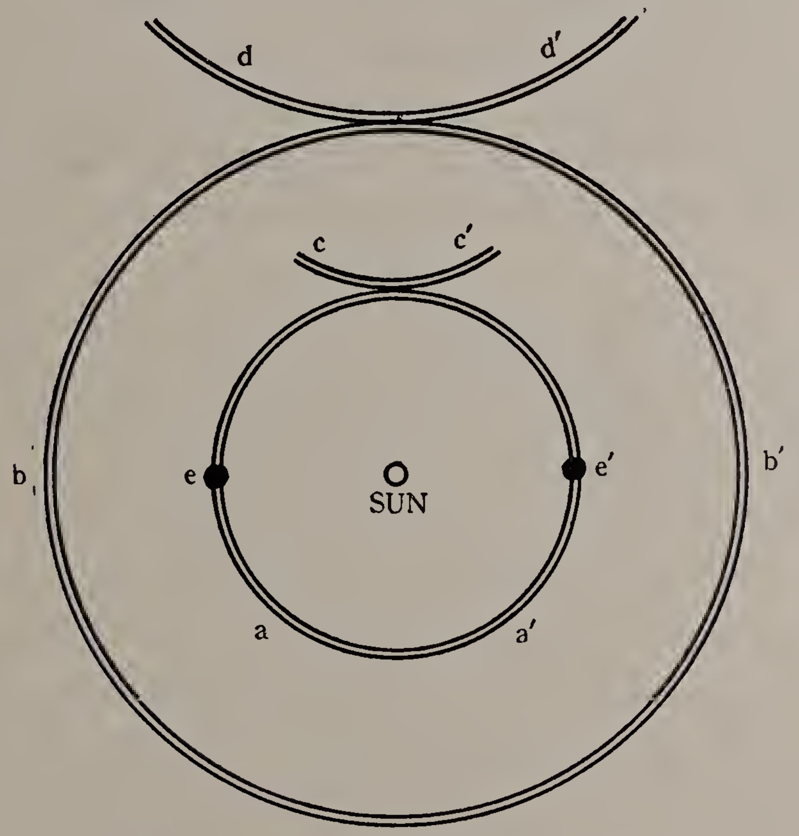

Fig I. The halo complex of March 4th, at St. Andrews, N. B.

the halo of 22°, bb′ the halo of 46°, ee′ the parhelia of 22°, and dd′ the circumzenithal arc[1]. The halos were brilliantly coloured, as in the rainbow, but notes were not made either of the colours present or the relative positions of the colours. The sky was noted as "leaden sky" but the particular type of cloud formation was not recorded.

A general description of optical atmospheric phenomena is furnished in a publication of the Canadian Department of Marine[2]. Attention is drawn therein to the so-called "arcs of contact", of which one, the upper tangent arc, is referred to in particular as being well known. In this connection, a feature of the halo complex herein described, and which was given particular attention, was an upper contact arc cc′ of the halo of 22° (see Fig. I). To the eye, this arc would seem to be one of radius equal to that of the halo of 22°, and not concentric with the circumzenithal arc. The main feature would seem to be that it is of an inverted type and in this respect different from the more common forms described as "upper tangent arcs of the halo of 22°".

---

[1] Humphreys. *"Physics of the Air"*., McGraw-Hill Book Co., New York. **1929**. pp. 483-527.

[2] Department of Marine. *"Temperature, Precipitation, Wind and Weather"*, Ottawa. **1931**. pp. 31-38.

FRESH WATER CLADOCERA AND COPEPODA FROM NEW BRUNSWICK AND NOVA SCOTIA[1].

M. W. SMITH.

Atlantic Biological Station, St. Andrews, N. B.

(Received May 3, 1935).

ABSTRACT.

Planktonic Cladocera and Copepoda from several fresh waters in New Brunswick and Nova Scotia are listed. Characteristic species of the limnoplankton are the cladocerans; *Diaphanosoma leuchtenbergianum, Holopedium gibberum, Daphnia pulex pulicaria, Daphnia longispina hyalina, Bosmina longirostris, Leptodora kindtii,* and the copepods; *Epischura lacustris, Diaptomus minutus, Mesocylops obsoletus.*

In recent years the author has had occasion to visit several lakes and ponds in New Brunswick and Nova Scotia in connection with various aquicultural problems. Plankton samples have been usually secured during each visit, and in this manner considerable data upon the species of Cladocera and Copepoda associated together in these waters have accumulated.

From an examination of the literature, it is found that comparatively little has been published concerning the fresh water plankton of the Maritime Provinces. This is particularly true of the limnetic plankton. Juday[2], Klugh[3] and Willey[4] have reported several species of Cladocera and Copepoda from samples collected at various points in the region. Klugh[5] gives lists of the forms associated with each other in a number of small ponds in Charlotte county, New Brunswick, and Smith[6] indicates certain species occurring in experimental ponds at the Atlantic Biological Station. Therefore, in view of this situation, it is considered worthwhile to present our data in this short paper.

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[1] This paper is published with permission of the Biological Board of Canada.
[2] Juday. *Canad. Field-Nat.* **40**, 99-100 (1926).
[3] Klugh. *Canad. Field-Nat.* **40**, 133-135 (1926).
[4] Willey. *Contr. Canad. Biol. Fish.*, N. S. **1**, 305-334 (1923).
[5] Klugh. *Trans. Roy. Canad. Inst.* **16**, 15-98 (1927).
[6] M. W. Smith. *Trans. Amer. Fish. Soc.* **62**, 317-322 (1932); *J. Biol. Bd. Can.* **1**, 67-93 (1934).

THE WATERS.

Samples were secured from four lakes and one pond in New Brunswick, and from four lakes and one slow-flowing stream in Nova Scotia. A short description of these bodies of water follows.

NEW BRUNSWICK.

1. Chiputneticook lakes[7], York county. (July 19, 1931). These lakes form a chain at the head-waters of the St. Croix river, and also form part of the international boundary between Canada and the United States. Only the first lake was visited, in which a maximum depth of 8.0 metres was found. The pH value of the water was 7.0 to 7.1.

2. Crecy lake, Charlotte county. (September 28, 1931). Crecy lake is a small body of water tributary to the Bocebec river. A maximum depth of 4.2 metres was sounded.

3. Lochs Lomond, St. John county. (August 30, 1932). These form a series of three lakes at the head of the Mispek river. Samples were secured from the first and third lakes. First Loch Lomond is the largest and deepest (40.5 metres), while third Loch Lomond is comparatively small and shallow (8.5 metres).

4. Stephenson's pond, St. John county. (June 28, July 19, October 5 and November 2, 1934). This pond has been formed artificially by damming a small brook flowing into first Loch Lomond. It was not filled to capacity during 1934 until October, at which time a depth of 1.7 metres was found at the dam. The pH value of the water varied from 5.8 to 6.0.

NOVA SCOTIA.

1. Lake George, Yarmouth county. (September 11, 1932). Lake George has an area of approximately 8 square miles. A maximum depth of 12.5 metres has been sounded and the mean depth estimated at about 5.5 metres. The surface water had a pH value of 6.5.

[7] This survey was made in co-operation with Dr. R. H. M'Gonigle. *Atl. Biol. Sta., Biol. Bd. Can.* Ms. Rep. **57**.

2. Hectanooga lake, Digby county. (October 3, 1934). This is a small lake (approximate area of 60 acres) tributary to the Salmon river, Digby county. A maximum depth of 5.5 metres was found. The mean depth approximates 3.5 metres. The pH value of the water was 6.6 to 6.7.

3. Lake Jesse, Yarmouth county. (July 31 to August 8, October 3, 1934). This lake covers an area of 45 acres and has a maximum depth of 6.0 metres, with a mean depth of 2.5 metres. It is tributary to Salmon river, Yarmouth county. The water had a pH value of 6.3 to 6.5.

4. Lake Annis, Yarmouth county, (August 3, 1934). Lake Annis is tributary to Salmon river, Yarmouth county. It receives the overflow from Lake Jesse.

5. Sullivan's flowage, Digby county. (August 8, 1934). Sullivan's flowage in part constitutes a slow-flowing stream on the headwaters of the Carleton branch of the Tusket river. A striking feature of the water was its very deep brown colour ("bog water"). A pH value of 5.3 was determined. Part of this flowage is dammed during the fall, winter and spring.

The phytoplankton of the above lakes, as far as it has been examined, is characterized by an abundance of desmids. On this basis, the lakes can be classified as belonging to the Caledonian type, in distinction from the Baltic type, in which the phytoplankton is dominated by Chlorococcales and Myxophyceae.

THE CLADOCERA AND COPEPODA.

In Table 1 a list of the species found in the plankton samples is given. From this list it may be seen that, in the open-water plankton, or limnoplankton, of the lakes, the cladocerans, *Diaphanosoma leuchtenbergianum*, *Holopedium gibberum*, the two species of *Daphnia*, their subspecies and forms, *Bosmina longirostris*, and *Leptodora kindtii*, and the copepods, *Epischura lacustris*, *Diaptomus minutus* and *Mesocyclops obsoletus*, are the most characteristic. The species of Cladocera are usually common, and often abundant, depending upon the season, except the predaceous *Leptodora*. which, although customarily present, never becomes numerous,

TABLE 1. LIST OF SPECIES OF CLADOCERA AND COPEPODA

SPECIES	Chiputneticook	Crecy	Loch Lomond 1	Loch Lomond 3	Stephenson's	George	Hectanooga	Jesse	Annis	Sullivan's
Diaphanosoma brachyurum (Liéven)	x	..	x	..	..	x	x	x	x	..
Diaphanosoma leuchtenbergianum Fischer	..	x	x	x	..	x	..	..	..	..
Holopedium gibberum Zaddach	x	..	..	..	..	x	x	x	x	..
Holopedium sp	..	..	..	x	..	..	..	..	..	..
Daphnia pulex pulicaria Forbes	x	..	..	..	..	x	x	x	x	..
Daphnia retrocurva Forbes	..	..	..	x	..	..	..	..	..	..
Daphnia longispina hyalina Leydig	x	x	x	x	..	x	..	..	..	..
Daphnia longispina hyalina Leydig forma *galeata*	..	..	..	..	..	..	..	x	x	..
Simocephalus serrulatus (Koch)	..	..	..	..	x	..	..	..	..	..
Scapholeberis mucronata (O. F. Müller)	..	..	..	..	x	..	..	..	..	x
Bosmina longirostris (O. F. Müller)	..	x	..	x	x	x	x	x	x	x
Bosmina longispina Leydig	x	..	x	..	..	..	..	..	..	..
Eurycercus lamellatus (O. F. Müller)	..	..	..	..	x	..	..	..	..	..
Acroperus harpae Baird	..	..	..	..	x	..	..	..	..	..
Alona affinis (Leydig)	..	..	..	..	..	..	..	x	..	x
Graptoleberis testudinaria (Fischer)	..	..	..	..	..	..	..	..	..	x
Rhynchotalona falcata (Sars)	..	..	..	..	..	..	..	x	..	..
Pleuroxus provurcatus Birge	..	..	..	..	x	..	..	..	..	..
Chydorus bicornutus Doolittle	..	..	..	..	..	..	..	..	..	x
Chydorus sphaericus (O. F. Müller)	..	..	..	..	x	..	..	..	..	..
Alonella nana (Baird)	..	..	..	..	..	..	..	x	..	..
Polyphemus pediculus (Linné)	x	..	..	..	x	x	..	x	..	..
Leptodora kindtii (Focke)	x	x	x	x	..	x	x	..	..	..
Epischura lacustris Forbes	x	x	x	x	..	x	x	x	x	..
Diaptomus minutus Lilljeborg	x	x	x	x	..	x	x	x	x	..
Diaptomus spatulocrenatus Pearse	x	..	..	..	..	..	..	..	..	..
Cyclops viridis americanus Marsh	..	..	..	..	x	..	..	..	..	..
Cyclops viridis brevispinosus Herrick	..	..	..	..	..	x	..	..	..	..
Mesocyclops obsoletus (Koch)	x	x	x	x	..	x	x	x	x	x
Eucyclops agilis (Koch)	..	..	..	..	x	..	..	x	..	x
Eucyclops prasinus (Fischer)	..	..	..	..	x	..	..	..	x	..
Ectocyclops phaleratus (Koch)	..	..	..	..	..	..	..	x	..	..

Of the Copepoda, the dominants are *Diaptomus minutus* and *Mesocyclops obsoletus*. These two species are almost invariably abundant and form a striking feature of the plankton in these lakes. *Epischura lacustris* was found more plentiful in the late summer and fall samples.

The above species of cladocerans are widely distributed in the lakes of temperate North America, as are the copepods, *Epischura lacustris* and *Mesocyclops obsoletus*. *Diaptomus minutus* is restricted to the northeastern part of the continent. According to Marsh[8] it is a cold-water form and, in its southern range, largely confined to the deeper lakes. However, in New Brunswick and Nova Scotia it is abundant in shallow lakes at the surface, where temperatures of 20-25°C. are reached during the summer.

On the whole the species of the genus *Diaptomus* tend to be limited in their distribution, but it is surprising that this genus is so poorly represented in the limnoplankton of the Maritime lakes. Besides *Diaptomus minutus*, *Diaptomus spatulocrenatus* was the only other species found, and then but sparingly in the first Chiputneticook lake. In central and western North America, on the other hand, several species of this genus may be taken in the same plankton sample, or in neighbouring lakes[9].

ADDITIONAL REMARKS ON CERTAIN SPECIES.

Diaphanosoma brachyurum and *Diaphanosoma leuchtenbergianum*. These two species of cladocerans are usually differentiated by the length of antennae, size of eye and size of body. Birge[10] says it is probable that the latter is only a limnetic variety of the former. Specimens from Lake George exhibited gradations from the characteristics of one to those of the other.

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[8] Marsh. *Proc. U. S. Nat. Mus.* **75**, 1-27 (1929).

[9] Bajkov. *Contr. Canad. Biol. Fish., N. S.* **5**, 383-422 (1930). Eddy. *Ill. Biol. Mon.* **12,** 1-93 (1934).

[10] Birge. Cladocera, in Ward and Whipple's "Fresh-water Biology." John Wiley and Sons, New York. **1918**, pp. 676-740.

Holopedium sp. A new species of *Holopedium* has been found in the third Loch Lomond and in the Chamcook lakes, Charlotte county, New Brunswick. A description of this species is being prepared.

Acroperus harpae. Specimens were secured from Stephenson's pond on October 5, 1934, which agreed with the description of *Acroperus harpae,* except that the post-abdomen was decidedly longer and narrower. This character is that of the closely related *Acroperus angustatus.* Birge[10] notes that transition forms between these two species have been found.

Diaptomus spatulocrenatus. The specimens from the first Chiputneticook lake had the left endopodite of the male fifth foot one-segmented, agreeing with individuals secured by Marsh[8] from Lake Sebago, Maine, but not in this particular with those originally described by Pearse[11] from Nantucket Island, in which specimens the endopodite was two-segmented.

The identification of *Eucyclops prasinus* from Stephenson's pond and of *Mesocyclops obsoletus* from Sullivan's flowage was kindly checked by Dr. Chas. B. Wilson.

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[10] Birge. Cladocera, in Ward and Whipple's "Fresh-water Biology. John Wiley and Sons, New York. **1918,** pp. 676-740.

[11] Pearse. *Amer. Nat.* **40,** 241-251 (1906).

THE MARINE FISHES OF NOVA SCOTIA

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ABSTRACT.

The present paper describes 151 species, belonging to 134 genera and 82 families, which occur in the Nova Scotian region. Among them, 17 may be found in both fresh and salt water, while the remainder are truly marine fishes. The latter group may be divided into three categories,—permanent residents (76), southern species (46) and northern fishes (12). The explanation of such a mixture of faunistic elements lies in the fact that, during the late summer months (August to October), the temperature of the upper layers of water along our shores increases greatly (up to about 68°F.), while during the early spring (January to April) the temperature drops to almost 30°F. Hence, southern fishes can easily stray to our coast during the warm season and the northern forms do the same during the late winter and early spring. On the whole the Nova Scotian fishes are rather typical species of mid-Atlantic latitudes.

INTRODUCTION.

The authors, under the Biological Board of Canada, have been engaged in research on certain commercial fishes of the Canadian Atlantic coast during the period 1931-35. Numerous requests to name fishes from various localities, to give suggestions concerning their means of identification, and to estimate the number of species found in Nova Scotian waters have influenced them to prepare this paper on all the marine fishes of this region.

The main object of this work is to give a comprehensive key by means of which anyone may identify the fishes, commercial and non-commercial, of Nova Scotian waters, since no such key exists. It is necessary to treat all species alike since the non-commercial fishes of to-day may be the important ones of to-morrow.

A complete review is given of all the marine and anadromous fishes (151 species) found around the Nova Scotian coast, with the exception of the Gulf of St. Lawrence. The area under consideration is bounded on the northeast by Cabot Strait and the Laurentian Channel, and on the south by the Atlantic Slope and the Fundian Channel. The coastal waters, about twenty miles in width, along the Nova Scotian coast of the Bay of Fundy have been considered as the western and northwestern boundary of this region. Figure I shows the extent of this region in detail.

In general, this Nova Scotian region, extending from north latitude 42° 15′ to 47° and from west longitude 57° to 66° 45′, covers approximately fifty thousand square miles of coastal and "bank" waters. The depth of water rarely exceeds two hundred fathoms.

The present paper is based on the personal examination of 120 species collected in the region under survey and completed by the inclusion of 31 additional species described in the literature.

The authors are deeply grateful to all those who have facilitated their task: to the Biological Board of Canada for working facilities; to Doctors A. H. Leim and D. B. Finn for kind permission to examine the museum specimens at the Fisheries Experimental Station, Halifax; to Harry Piers, Esq., Curator of the Provincial Museum, Halifax, for valuable assistance and kind permission to examine Museum specimens. Mention should be made also of the many specimens of rare fishes brought from the "banks" by Captains Frank Tidman and H. S. Hansen, and Mr. J. Mahar, Radio Operator. The inshore fishes were procured through the kindness of Captain A. E. Calder, Research Vessel *Zoarces*, and Mr. C. K. Darrach of the Fisheries Experimental Station.

Thanks are due also to Mrs. R. A. McKenzie who has kindly typed the entire manuscript and made numerous helpful corrections.

IDENTIFICATION OF FISHES.

REMARKS ON THE KEY.

Due to the fact that the aim of this Key is to facilitate the non-specialist in the identification of native fishes, it has been made in a rather simple way. Hence, as a rule, only external and the more conspicuous characters have been used. In the characteristics of genera and families, only those char-

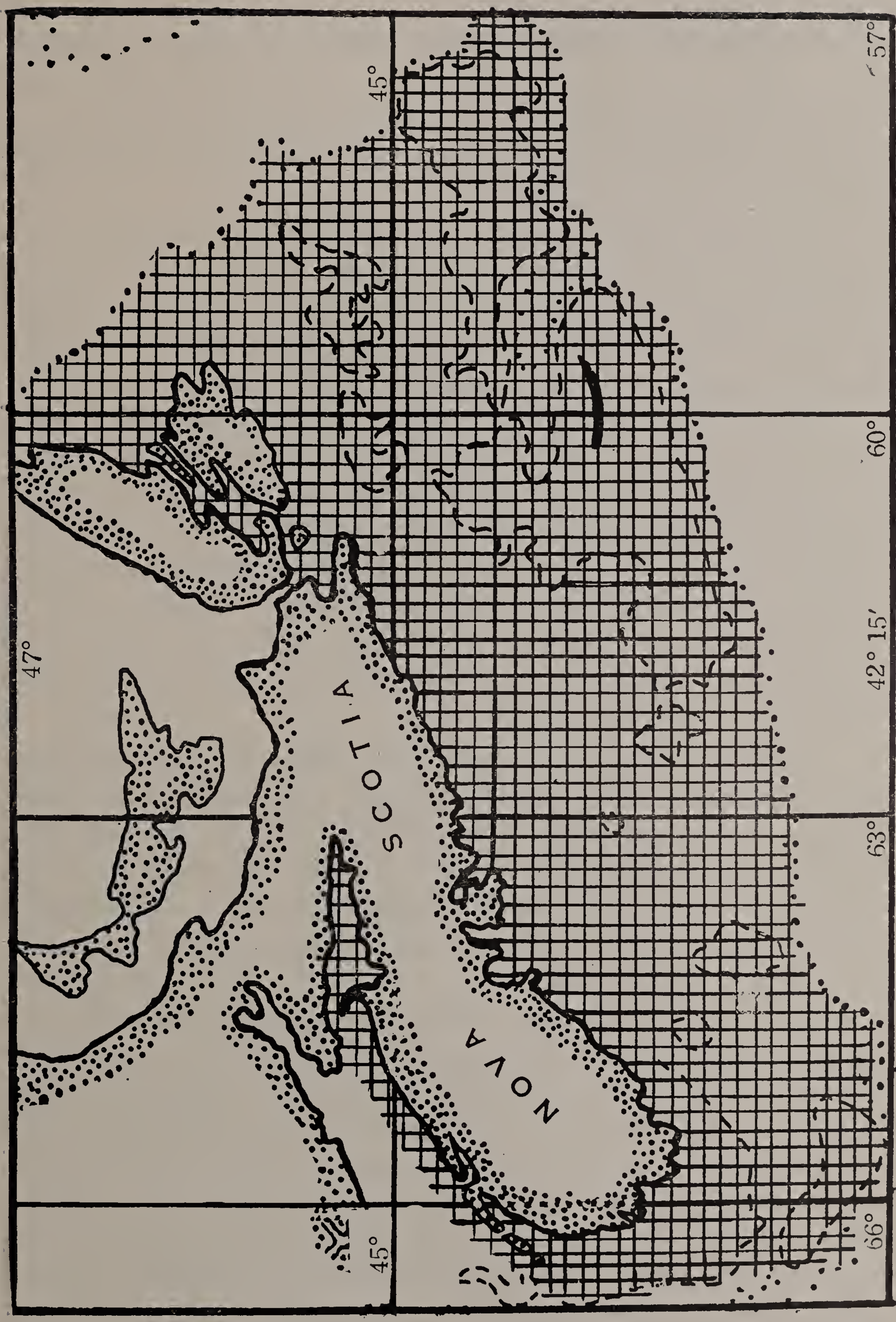

Fig. I—Map of Nova Scotian region. Cross-hatching shows the extent of the area under consideration.

acters, which are typical of the fishes present in our area, have been considered. Because of this, our Key is rather artificial, and is limited in use primarily to the area under consideration. However, it may be used in all the Maritime Provinces of Canada, except for a few species which have not been found in the Nova Scotian region.

The traditional method of making a key has been to use a complex system of letters or numerals in the identification of a specimen. Instead of this, we have used the simpler method of IF and BUT IF which has been applied to good effect by Walford[1] for the fishes of California.

To use this "self-directing" Key, simply read both parts of the first Section where further directions will be found. It is necessary, first of all, to compare the characteristics listed there with those of the fish in hand. Then it must be decided into which part of the Section the specimen in hand belongs. When this is done, follow the instructions given in that part of the Section, continuing this procedure until finally the scientific name of the family to which your specimen belongs, is determined.

If a common name for the fish is mentioned in that Section, then your identification is finished. The scientific name (generic and specific) for your fish is given in the chapter, *Description of Fishes*, under the title of the family to which it belongs. This family may be readily found by reference to the Roman numerals in front of the scientific family names in the Key for Families.

In the case, however, where the common name for the fish is replaced by the statement, "a member of —— family," then see the key for the genera or species of this particular family in the Description of Fishes, in order to finally name your fish.

However, it may happen that certain specimens of fishes will not be identifiable as far as the specific name by using this Key. In such a case, the probability is that the fish is a strange and unusual species for the region, and it is urged that such a specimen (with information on date and place of capture) be sent to the authors at the Fisheries Experimental Station, Halifax, N. S.

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[1] Walford. *Div. Fish Game, Calif., Fish. Bull.*, 28, 183 pp. (1931).

In this Key the most important characters are mentioned first in every Section. The numbering of the Sections in each part of the Key is done independently.

The Key for Families has been divided, primarily, into a General Part and a Specific Part. The former is the guide to the three large Divisions treated in the Specific Part. Division I and Division II are not subdivided, but Division III has three smaller Subdivisions.

A brief statement of the main characters in each of these three Divisions is set forth here. The Lamprey and Hag, belonging to the first Division, are easily recognized by the absence of paired fins and by the presence of naked snake-like bodies. The Sharks, Skates and Chimaera are considered in the second Division. The first two groups have at least 5 pairs of gill slits without covering, while the Chimaera have only 1 gill opening on each side of the head, and each opening is enclosed by a flap of skin. All the fishes of this second Division have, in common, a thick leathery skin on body and head which covers the fins also, and the males have the inner part of the ventral fins modified into claspers.

The third Division is the most complicated, embracing Bony Fishes. The Sturgeon with 5 rows of large, bony shields running lengthwise of the body and an elongated, flattened, shovel-like snout cannot be confused with any other fish.

The remaining great majority of fishes are listed in three subsequent Subdivisions. Each Subdivision is characterized by the difference in development, structure and position of the ventral fins. The first Subdivision includes the fishes without ventral fins, such as the Eel group, Catfish, Swordfish, Pipefish, etc., and fishes with ventral fins modified into a sucking disc as Lumpfish and Sea Snail. The second Subdivision embraces fishes with ventral fins in a thoracic and jugular position, Mackerel and Codfish types, respectively. The remaining fishes, which are considered in the third Subdivision, have the ventral fins in an abdominal position, as in the case of Herring and Salmon.

To facilitate the use of the Key, 129 drawings of various fishes have been included. At least one representative of each of the 82 families mentioned in this paper has been depicted, and in the case of economically important families or curious species, additional drawings have been prepared.

These drawings are semi-schematic, and the more important systematic characters, as, for example, adipose fins, maxillaries, etc., have been shown in solid black to make them more conspicuous. As a rule, the exact number of spines in the first dorsal and anal fins are indicated in the drawings when such characters are of importance in identification. For the same reason, on some occasions, scales and colour patterns are also shown.

The great majority of the drawings are taken from the fourth volume of the celebrated treatise of Jordan and Evermann[2], while the remaining drawings are taken from other authors as follows: Figs. VI, VII, XXXIX, XLV, LXIII, CXII and CXXIX from Bigelow and Welsh[3]; Figs. XIII, XIV and XVIII from Bigelow and Schroeder[4]; Figs. XLIII, XLIV and LXXXVII from Goode and Bean[5]; Figs. IV, XVI, XVII and XIX-XXIII from Garman[6]; Figs. LXIV and LXVI-LXXI from Huntsman[7]; Figs. CXX-CXXII from Jensen[8]; Figs. XII, LXI and LXXXV from La Gorce[9] and Fig. CXIV from Beebe[10]; Figs. LII and CVII from Knipovich[11]; Figs. XV, XXXIV, XLVI, CXVIII and CXXX from

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[2] Jordan and Evermann. *Bull. U. S. Nat. Mus.* No. **47**, 3313 pp. (1896-1900).

[3] Bigelow and Welsh. *Bull. U. S. Bur. Fish.*, **40**, Pt. I, 567 pp. (1925).

[4] Bigelow and Schroeder. *Can. Atlant. Fauna*, **12**, 38 pp. (1934).

[5] Goode and Bean. "Oceanic Ichthyology." *Spec. Bull. U. S. Nat. Mus.*, 1895, 553 pp.

[6] Garman. *Mem. Mus. Comp. Zool. Harvard*, **36**, 515 pp. (1913).

[7] Huntsman. *Can. Fisherman*, **5**, 788-790 (1918).

[8] Jensen. *"The Danish Ingolf-Expedition,"* **2**, Pt. 4 (1904).

[9] LaGorce. *Nat. Geog. Mag.*, **44**, 567-634 (1923).

[10] Beebe. *Nat. Geog. Mag.*, **61**, 87 (1932).

[11] Knipovich. *Trans. Inst. Scient. Explor. North*, No. **27**, Moscow (1926).

Gowanloch, Koelz, Parr, Gill and Gregory[12] respectively. Figs. V, XXXI-XXXIII and XXXVIII are original.

A short glossary, which follows, explains the meaning of the technical terms unavoidably used throughout the paper.

GLOSSARY OF TECHNICAL TERMS.

ABDOMINAL POSITION OF VENTRAL FINS.—Far behind the pectoral fins.

ADIPOSE FIN.—A small, soft, fleshy dorsal fin that has no supporting rays, located behind the first dorsal fin and close to the caudal fin.

AIR BLADDER.—Commonly known as the "sound." The sack within the body cavity just below the backbone and containing gases.

ANADROMOUS.—Fishes which live in salt water but go into fresh water to spawn, e. g. Salmon, Shad, etc.

ANAL FIN.—The unpaired fin or fins (two) on the lower surface of the body just behind the vent.

ANUS.—The external opening of the intestine located in front of the anal fin.

ANTERIOR.—Referring to the front part.

BASE OF FIN.—Extent of the fin from the base of the first ray to the base of the last ray. This term applies only to the vertical fins.

BARBEL.—A slim, fleshy appendage located on the front of the head around the mouth or nostrils.

BODY DEPTH.—The greatest vertical diameter of the fish.

BODY LENGTH.—The length of the fish from the foremost part of the head to the end of the backbone. (Caudal fin not included).

BRANCHIOSTEGAL RAYS.—The rays supporting the Gill Membrane, the latter being a fleshy extension of the lower part of the gill covers.

CAUDAL FIN.—The fin on the rear end of the body, commonly called the "tail fin."

CLASPERS.—Semi-tubular, rod-like modifications of the ventral fins in the males of sharks, skates and chimaera, serving for mating purposes.

DIAMETER OF EYE.—Only the horizontal diameter is understood.

DORSAL.—Referring to the back or upper surface.

DORSAL FIN.—The unpaired fin or fins (two or three) on the back of the fish.

FINLET.—One or several very small fins possessing rays, located behind the normal dorsal and anal fins, found, for example, in Mackerel.

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[12] Gowanloch. *Dept. Conserv. State Louisiana, Bull.* **23**, p. 219 (1933); Koelz, *Bull. U. S. Bur. Fish.*, **43**, 516-517 (1929); Parr, *Proc. U. S. Nat. Mus.*, **76**, Art. 10, p. 43 (1929); Gill, *Proc. U. S. Nat. Mus.*, **39**, 157-188 (1911); Gregory, *Nat. History*, **28**, p. 9, (1928).

FIN RAYS.—The supporting rods of a fin. When they are branched at the top and are quite flexible, they are called Soft Rays, but when they are stiff and usually sharply pointed, they are called Spiny Rays or just Spines. Sometimes certain rays are greatly elongated, "whip-like," and these are called Filamentous Rays.

GILL COVERING.—The bony cover which protects the gills.

GILL OPENINGS.—The external openings leading to and from the gills.

GILLS.—The respiratory organs of fishes, consisting of numerous, thin, feathery filaments (bright red in a live fish) attached to the supporting arches found within the gill openings.

GILL RAKERS.—Short, stiff rods located on the gill arches opposite to the gill filaments.

HEAD LENGTH.—Distance between the foremost part of the head and the hindmost part of the gill cover.

HEIGHT OF FIN.—The length of the longest ray in the fin; applicable *only* to the *vertical fins.*

ISTHMUS.—The narrow, triangular part on the lower surface of the head in front of the pectoral fins, and between the gill clefts.

JUGULAR POSITION OF THE VENTRAL FINS.—In front of the pectoral fins close to the isthmus.

LANDLOCKED.—Said of certain individuals of anadromous fishes which never descend to the sea but live permanently in fresh water.

LATERAL.—Referring to the side.

LATERAL LINE.—A line of pores extending along the side of the body giving the impression of a dotted line.

LENGTH OF FINS.—The distance from the upper edge of the base to the tip of the fin (not the length of the longest ray) and is applicable *only* to the *paired fins.*

LUMINOUS ORGANS.—Organs in some fish (e. g. Lanternfish) which give off light. Those on the front of the head are larger and of various shapes, while those on the sides of the head and on the body are small and round in shape (so-called photophores).

LUMINOUS SCALES.—Scales giving off light found on the upper or lower surface of the tail.

MAXILLARY.—The outermost bone on each side of the upper jaw joined in front to another bone (*premaxillary*) and extending backwards, the hind ends of which move downwards when the mouth is opened.

OPERCLE.—The principal bone in the gill covering, located immediately behind the cheek.

PAIRED FINS.—These are the ventral and pectoral fins; one of each pair being located on either side of the fish.

PALATINES.—A pair of bones lying in the roof of the mouth; one on each side of the vomer. These palatine bones may possess teeth,—palatine teeth.

PECTORAL FINS.—The anterior or uppermost pair of fins, located on the side of the fish immediately behind the head.

PELAGIC.—Referring to fishes (or other organisms) usually found in the upper water layers.

PHOTOPHORES.—See Luminous Organs.

POSTERIOR.—Referring to the rear part.

SNOUT.—The front part of the head from the tip of the upper jaw to the eye.

TOTAL LENGTH.—The length of the fish from the foremost part of the head to the hindmost part of the caudal fin. (This fin included).

THORACIC POSITION OF THE VENTRAL FINS.—Below the pectoral fins.

VENT.—Same as Anus.

VENTRAL.—Referring to the belly or lower surface.

VENTRAL FINS.—The pair of fins located on the lower surface of the fish behind, below or in front of the pectoral fins.

VERTICAL FINS.—These are the dorsal, anal and caudal fins.

VERTEBRAE.—Joints of the backbone.

VOMER.—An unpaired bone, often bearing teeth (vomerine teeth), located between the palatine bones in the middle of the roof of the mouth just behind the middle of the upper jaw.

KEY FOR FAMILIES.—GENERAL PART.

Section 1.

IF: Paired fins absent; body snake-like; head not distinct from body; mouth without jaws (Lamprey type); several small, rounded gill openings along the side or on lower surface of front part of body (Figs. II and XIII):—see Division I, p. 26.

BUT IF: At least one pair of paired fins (pectoral) present; body snake-like or of another shape; head distinct from body; mouth with jaws; several slit-like gill openings (Figs. III and V) present or only one gill opening (on each side) covered by a thin bony plate (Fig. X) or flap of skin (operculum):—see Section 2.

Section 2.

IF: As a rule, 5 to 7 gill slits on each side (Shark type, Fig. III) or on lower surface (Skate type, Fig. V) of the head; inner part of ventral fins in male sex modified into claspers; leathery skin naked or covered with minute bony plates, spines, etc., instead of scales; fins covered with leathery skin through which rays are not or hardly visible; skeleton chiefly cartilaginous, not true bone:—see Division II, p. 26.

BUT IF: Only one gill opening covered by thin, bony plates on each side of the head (Bony fish type, e. g. Haddock, Fig. X); ventral fins not modified into claspers; skin covered with scales, bony plates or naked; fins consisting of thin membrane through which fin rays are clearly visible, as a rule; skeleton more often bony than cartilaginous:—see Division III, p. 27.

KEY FOR FAMILIES.—SPECIFIC PART.

Division I.

Lampreys and Hags (*Marsipobranchii*).

IF: No eyes; front part of head bearing 6 barbels; horny teeth not visible in exterior part of mouth cavity; two gill openings on lower surface slightly in front of middle of body; low undivided finfold on back present only in tail region:—a Hagfish, Fig. XIII (see Fam. I, *Myxidinae*).

BUT IF: Small eyes present; barbels absent; numerous horny teeth clearly visible in disc-like mouth; 7 gill openings immediately behind eyes on each side of the head; dorsal finfold divided into 2 relatively high fins:—a Lamprey, Fig. II (see Fam. II, *Petromyzonidae*).

Division II.

Sharks and Rays (*Elasmobranchii*).

Section 1.

IF: Only 1 gill opening on each side covered with a flap of skin; the two dorsal fins and upper part of caudal fin giving the impression of one long continuous fin along the mid-line of body from head to rear end of fish; caudal fin tapering, ending in a filament; few teeth arranged in 3 pairs of edgewise dental plates:—a Chimaera, Fig. XXIV (see Fam. XII, *Chimaeridae*).

BUT IF: 5 to 7 slit-like gill openings without a covering; the two dorsal fins short, never extending over full length of fish; caudal fin not ending in a filament; numerous teeth in jaws:—see Section 2.

Section 2.

IF: Body definitely flattened from top to bottom (Skate type, Figs. IV and V), triangular or roundish in shape; gill slits located on lower surface of head:—see Section 3.

BUT IF: Body not flattened from top to bottom; gill slits located on sides of head (Shark type, Fig. III):—see Section 4.

Section 3.

IF: Outline of head and anterior part of body roundish; skin smooth without spines or prickles; caudal fin well developed, large and triangular; fish able to give an electric shock:—an Electric Skate, Fig. XXIII (see Fam. XI, *Torpedinidae*).

BUT IF: Outline of head and anterior part of body triangular; skin on upper surface with prickles or spines; caudal fin very small; fish unable to give an electric shock:—a member of the Skate family, Fig. IV (see Fam. X, *Rajidae*).

Section 4.

IF: Head hammer-shaped; eyes at end of lateral projections:—a Hammerhead Shark, Fig. XV (see Fam. IV, *Sphyrnidae*).

BUT IF: Head normal (Dogfish type, Fig. XX) without hammer-shaped projections:—see Section 5.

Section 5.

IF: Tail longer than body itself:—a Thresher Shark, Fig. XVI (see Fam. V, *Alopiidae*).

BUT IF: Tail less than one-half of body length:—see Section 6.

Section 6.

IF: Anal fin absent:—see Section 7.

BUT IF: Anal fin present:—see Section 8.

Section 7.

IF: Spine in front of each dorsal fin:—a member of the Dogfish family, Figs. XX and XXI (see Fam. VIII, *Squalidae*).

BUT IF: No spines in front of dorsal fins:—a Greenland Shark, Fig. XXII (see Fam. IX, *Somniosidae*).

Section 8.

IF: Gill slit very long nearly meeting under head; teeth minute (about 200 on each jaw):—a Basking Shark, Fig. XVIII (see Fam. VII, *Cetorhinidae*).

BUT IF: Gill slits not long, confined to sides of head only; teeth large (less than 50 on each jaw):—see Section 9.

Section 9.

IF: A strong keel at base of caudal fin; colour grayish:—a member of the Mackerel Shark family, Fig. III (see Fam. VI, *Isuridae*).

BUT IF: No keel present at base of caudal fin; colour decidedly bluish:—a Blue Shark, Fig. XIV (see Fam. III, *Carchariidae*).

Division III.

Bony Fishes (*Teleostei*).

Section 1.

IF: Snout elongated and flattened, shovel-like; 4 barbels present in front of small, round mouth located on lower surface of head; 5 rows of large, bony shields running lengthwise of body; skeleton cartilaginous; caudal fin (shark type) with upper lobe about twice as long as lower:—a Sturgeon, Fig. XXV (see Fam. XIII, *Acipenseridae*).

BUT IF: Snout not shovel-like; 4 barbels not present in front of mouth located on lower surface of head; 5 rows of bony shields not present; skeleton more often bony than cartilaginous; caudal fin rounded, forked, etc., not of the shark type:—see Section 2.

Section 2.

IF: Ventral fins absent (Eel type, Fig. XLI) or modified into a kind of sucking disc (Sea Snail type, Fig. VII):—see Subdivision 1, p. 28.

BUT IF: Ventral fins present and not modified into a sucking disc:—see Section 3.

Section 3.

IF: Ventral fins in jugular (Tuna type, Fig. VIII) or thoracic position (Haddock type, Fig. X):—see Subdivision 2, p. 30.

BUT IF: Ventral fins in abdominal position (Salmon type, Fig. XII):—see Subdivision 3, p. 36.

Subdivision 1.

Fishes with ventral fins absent (Eel type, Fig. XLI) or modified into a sucking disc (Sea Snail type, Fig. VII).

Section 1.

IF: Ventral fins modified into a sucking disc located immediately behind head on lower surface:—see Section 2.

BUT IF: Ventral fins completely absent:—see Section 3.

Section 2.

IF: 1 or 2 dorsal fins present, each of which and anal fin possessing less than 15 rays; second dorsal and anal fins separated by a considerable space from caudal fin; head and body covered with bony shields:—a member of the Lumpfish family, Fig. CVIII (see Fam. LXVII, *Cyclopteridae*).

BUT IF: Dorsal and anal fins, each possessing at least 30 rays, extending to or even connecting with caudal fin; head and body covered with a soft, loose, easily torn skin without bony shields:—a member of the Sea Snail family, Figs. VI and CIX (see Fam. LXVIII, *Liparidae*).

Section 3.

IF: Mouth armed, in addition to tusk-like teeth, with several very strong molars:—a member of the Catfish family, Fig. CXIX (see Fam. LXXV, *Anarhichadidae*).

BUT IF: Mouth toothless or possessing only small teeth, not molar-like:—see Section 4.

Section 4.

IF: Fish large; upper jaw and snout greatly prolonged into a flat, sharp-edged sword, about one-half as long as the body; a strong keel at base of caudal fin:—a Swordfish, Fig. LXXXV (see Fam. XLIX, *Xiphiidae*).

BUT IF: Fish large or small; upper jaw not sword-like; no keel at base of caudal fin:—see Section 5.

Section 5.

IF: Whole body covered with rings of bony plates; small mouth at tip of tube-like snout:—a member of the Pipefish family, Figs. LXXV and LXXVI (see Fam. XLIII, *Syngnathidae*).

BUT IF: Body covered with scales, spines or naked, not with rings of bony plates; snout not tube-like:—see Section 6.

Section 6.

IF: Fish large; roundish, not elongated; body depth not less than one-third of body length:—see Section 7.

BUT IF: Fish small; elongated; body depth not more than one-tenth of body length:—see Section 10.

Section 7.

IF: Caudal fin merely a flap of skin extending around the posterior edge of body; pectoral fins very small; dorsal and anal fins very high and opposite each other located close to the posterior end of fish; body having neither scales nor spines:—a Sunfish, Fig. CXXVIII (see Fam. LXXX, *Molidae*).

BUT IF: Caudal fin well developed; pectoral either long or short; body covered with scales or spines:—see Section 8.

Section 8.

IF: Body covered with scales; caudal fin deeply forked; dorsal and anal fins with at least 30 rays each:—a Dollarfish, Fig. LXXXVIII (see Fam. LII, *Stromateidae*).

BUT IF: Body covered with spines instead of scales; caudal fin rounded; dorsal and anal fins with less than 15 rays each, located close to caudal fin:—see Section 9.

Section 9.

IF: Mouth small; diameter of eye about one-fifth of head length; body covered with large spines; outline of free end of caudal fin uniformly rounded, not notched between rays; no long filamentous rays on head and back in front of dorsal fin:—a Burrfish, Fig. CXXVII (see Fam. LXXIX, *Diodontidae*).

BUT IF: Mouth large; diameter of eye not more than one-tenth of head length; body covered with minute spines; outline of free end of caudal fin deeply notched between rays; 2 long filamentous rays in front of dorsal fin (1 on back and 1 on head):—a Sea Devil, Fig. CXXX (see Fam. LXXXII, *Ceratiidae*).

Section 10.

IF: Caudal fin forked; dorsal and anal fins well separated from caudal; lower jaw protruding beyond upper:—a Sand Launce, Fig. CXIII (see Fam. LXXI, *Ammodytidae*).

BUT IF: Caudal fin rounded, both dorsal and anal fins connected with it; lower jaw protruding or not:—see Section 11.

Section 11.

IF: Dorsal fin possessing only spiny rays; this and anal fin continuous with caudal fin, but demarcation between all 3 fins clear; gill opening very large, wider than length of pectoral fin; mouth oblique:—a Ghostfish, Fig. CXVII (see Fam. LXXIV, *Cryptacanthodidae*).

BUT IF: Dorsal and anal fins, possessing only soft rays, continuous with caudal fin, no line of demarcation discernible; gill opening very small, equal in width to about one-half length of pectoral fin:—see Section 12.

Section 12.

IF: Gill opening situated above base of pectoral fin; both lips very thick; pectoral fin large, longer than one-half length of head; body rather stout, depth not less than one-eleventh of total length:—a Green Eelpout, Fig. CXXIV (see Fam. LXXVI, *Zoarcidae*).

BUT IF: Gill opening situated below base of pectoral fin; both lips thin; pectoral fin smaller, less than one-half length of head; body depth usually less than one-eleventh of total length:—see Section 13.

Section 13.

IF: Both jaws very long and bill-like, almost three times as long as head itself; body extremely slender, about seventy-five times longer than deep:—a Thread Eel, Fig. XLV (see Fam. XXVIII, *Nemichthyidae*).

BUT IF: Jaws not elongated and bill-like; body not more than twenty times longer than deep:—see Section 14.

Section 14.

IF: Mouth very small, posterior end of maxillary not reaching to below nostril; snout blunt, jaws powerful; 2 separate gill openings located on lower surface of head:—a Snub-nosed Eel, Fig. XLIII (see Fam. XXVI, *Simenchelyidae*).

BUT IF: Mouth rather large, posterior end of maxillary reaching at least to middle of eye; snout elongated, jaws weak; gill openings located on side or lower surface of head:—see Section 15.

Section 15.

IF: Posterior end of maxillary extending far behind eye; gill openings located on lower surface, united one with the other:—a Long-nosed Eel, Fig. XLIV (see Fam. XXVII, *Synaphobranchidae*).

BUT IF: Maxillary not extending beyond posterior part of eye; gill openings on side of head:—see Section 16.

Section 16.

IF: Dorsal fin beginning just behind pectoral fin, distance from tip of snout to beginning of dorsal fin less than twice length of head; jaws even:—a Conger Eel, Fig. XLII (see Fam. XXV, *Congridae*).

BUT IF: Dorsal fin beginning far back from pectoral fin, distance from tip of snout to first dorsal ray almost three times length of head; jaws uneven, lower projecting slightly:—a Common Eel, Fig. XLI (see Fam. XXIV, *Anguillidae*).

Subdivision 2.

Fishes with ventral fins in a thoracic (Tuna type, Fig. VIII) or jugular position (Haddock type, Fig. X).

Section 1.

IF: Ventral fins situated in thoracic position:—see Section 2.

BUT IF: Ventral fins situated in jugular position:—see Section 25.

Fishes with ventral fins in a thoracic position.

Section 2.

IF: Oval sucking disc on top of head extending onto anterior part of back:—a member of the Sharksucker family, Fig. CXII (see Fam. LXX, *Echeneidae*).

BUT IF: No sucking disc on head and back:—see Section 3.

Section 3.

IF: Ventral fin having only 2 rays, first being a strong spine and second soft; 2 to 12 strong, free spines in front of dorsal fin; all of ventral and dorsal spines able to be erected or depressed at will:—a member of the Stickleback family, Figs. LXXII-LXXIV (see Fam. XLII, *Gasterosteidae*).

BUT IF: Ventral fin having usually 6 rays (only 4 in the Sculpin family); spines, if present in front of dorsal fin, not able to be erected or depressed at will:—see Section 4.

Section 4.

IF: At least 2 finlets (Tuna type, Fig. VIII) behind both dorsal and anal fins:—see Section 5.

BUT IF: No finlets, or only 1, behind dorsal and anal fins:—see Section 6.

Section 5.

IF: At least 4 finlets behind both dorsal and anal fins; jaws about equal and armed with small teeth; keels (2-3) running lengthwise at base of caudal fin:—a member of the Mackerel family, Figs. VIII and LXXX-LXXXIII (see Fam. XLVII, *Scombridae*).

BUT IF: Only 2 finlets behind both dorsal and anal fins; lower jaw protruding greatly, both jaws armed with large teeth; keels absent:—an Oilfish, Fig. LXXXIV (see Fam. XLVIII, *Gempylidae*).

Section 6.

IF: Body tapering to a whip-like tail; anal fin as well as second dorsal fin continuous with caudal fin:—a member of the Rat-tail family, Fig. LII (see Fam. XXXIV, *Macrouridae*).

BUT IF: Body not tapering to a whip-like tail; anal and dorsal fins separated from caudal fin:—see Section 7.

Section 7.

IF: Thin, high, fleshy fin-like flap (without rays) in front of dorsal fin (shown black in Fig. XCVIII):—a Tilefish (see Fam. LX, *Branchiostegidae*).

BUT IF: No flap in front of dorsal fin:—see Section 8.

Section 8.

IF: Elongated body completely armed with several rows of bony plates, not with scales:—see Section 9.

BUT IF: Body not completely armed with plates, but naked or covered with scales:—see Section 10.

Section 9.

IF: 2 dorsal fins; at least 5 barbels on each side of head:—a Northern Alligatorfish, Fig. CVII (see Fam. LXVI, *Agonidae*).

BUT IF: Only 1 (second) dorsal fin; barbels absent:—a Common Alligatorfish, Fig. CVI (see Fam. LXV, *Aspidophoroididae.*

Section 10.

IF: Head and body naked or only partially covered with bony plates, not regularly scaled:—see Section 11.

BUT IF: Head, body or both covered with regular scales or partially naked (in the latter case lateral line arched over pectoral fin):—see Section 13.

Section 11.

IF: Caudal fin forked; body entirely naked; no spines on head; teeth long and movable:—a Black Swallower, Fig. CXIV (see Fam. LXXII, *Chiasmodontidae*).

BUT IF: Caudal fin rounded; body with some bony plates; spines on head present and well developed; teeth small:—see Section 12.

Section 12.

IF: Several fleshy flaps on head; membrane between upper parts of rays of first dorsal fin deeply notched; this fin much longer than second dorsal: —a Sea Raven, Fig. CV (see Fam. LXIV, *Hemitripteridae*).

BUT IF: No fleshy flaps on head; membrane practically unnotched between rays of first dorsal, this fin shorter than second dorsal, or if only 1 dorsal present and spiny part much shorter than soft rayed part:—a member of the Sculpin family, Figs. CI-CIV (see Fam. LXIII, *Cottidae*).

Section 13.

IF: Fish of large size; ventral fin possessing 14 to 17 rays; mouth toothless; body deep and covered with minute scales:—an Opah, Fig. LXIII (see Fam. XXXVIII, *Lampridae*).

BUT IF: Fish usually of smaller size; ventral fin with no more than 6 (1 spine and 5 soft) rays; mouth with teeth; body of various shapes; scales large, minute or partially wanting:—see Section 14.

Section 14.

IF: 2 long barbels on chin; 2 well separated dorsal fins; body and head covered with rather large scales:—a Red Mullet, Fig. XCVII (see Fam. LIX, *Mullidae*).

BUT IF: No barbels on chin; 1 or 2 dorsal fins present, (in latter case both fins separated, united or the first reduced to a few spines); scales small or large:—see Section 15.

Section 15.

IF: 1 or 3 keels at base of caudal fin (keels absent in *Argyreiosus vomer,* Fam. LIV, *Carangidae,* but body of this fish very thin and deep, lateral line arched, anterior rays of both second dorsal and anal fins pronouncedly elongated, ventral fin shorter than diameter of eye); lateral line usually arched:—see Section 16.

BUT IF: No keels at base of caudal fin; lateral line usually straight:—see Section 17.

Section 16.

IF: Pectoral fin much longer than ventral fin; lateral line arched or straight; colour silvery without transverse black bands:—a member of the Hardtail family, Figs. XC-XCII (see Fam. LIV, *Carangidae*).

BUT IF: Pectoral fin slightly shorter than ventral fin; lateral line straight; usually 6 transverse black bands on side:—a member of the Pilotfish family, Fig. XCIII (see Fam. LV, *Seriolidae*).

Section 17.

IF: 2 clearly separated dorsal fins, the first consisting of only a few spines:—see Section 18.

BUT IF: Only 1 dorsal fin, anterior part of which may consist of spines:—see Section 19.

Section 18.

IF: First dorsal fin much shorter and lower than second; anal fin long (about 25 rays); mouth large with posterior part of maxillary extending behind eye:—a Bluefish, Fig. XCIV (see Fam. LVI, *Pomatomidae*).

BUT IF: 2 dorsal fins practically equal in length and height; anal fin short (about 15 rays); mouth small with posterior end of maxillary scarcely reaching middle of eye:—a member of the White Bass family, Figs. XCV and XCVI (see Fam. LVII, *Moronidae*).

Section 19.

IF: Dorsal fin exceptionally long (55 to 65 rays) extending from immediately behind head nearly to caudal fin; caudal fin deeply forked:—a Dolphin, Fig. LXXXVI (see Fam. L, *Coryphaenidae*).

BUT IF: Dorsal fin shorter (less than 40 rays) beginning some distance behind head; caudal fin of different shapes:—see Section 20.

Section 20.

IF: Spines in anterior part of dorsal fin weak, not conspicuously developed and not more than 5 in number; length of pectoral fin much greater than that of head; ventral fin short, being about one-third as long as pectoral fin; caudal fin deeply forked:—a Sea Bream, Fig. LXXXVII (see Fam. LI, *Bramidae*).

BUT IF: At least 6 strong, conspicuous spines in anterior part of dorsal fin; length of pectoral fin less than that of head; ventral fin about equal in length to pectoral fin; caudal fin rounded or only slightly forked:—see Section 21.

Section 21.

IF: At least 15 soft rays in anal fin:—see Section 22.

BUT IF: Less than 12 soft rays in anal fin:—see Section 23.

Section 22.

IF: 6 to 8 small spines, about one-third height of soft rays, in front of dorsal fin; maxillary reaching to about middle of eye:—a Barrelfish, Fig. LXXXIX (see Fam. LIII, *Centrolophidae*).

BUT IF: At least 8 large spines in dorsal fin about equal in height to soft rays; maxillary not reaching to front of eye:—a Common Butterfly Fish, Fig. XCIX (see Fam. LXI, *Chaetodontidae*).

Section 23.

IF: Mouth small, maxillary not reaching front of eye; spiny part of dorsal fin (14-18 spines) considerably longer than soft ray portion (9-10 rays); caudal fin rounded:—a member of the Cunner family, Figs. CX and CXI (see Fam. LXIX, *Labridae*).

BUT IF: Mouth large, maxillary reaching at least to middle of eye; number of spines in dorsal fin less than or equal to number of soft rays; caudal fin slightly forked, squarish or rounded:—see Section 24.

Section 24.

IF: Eye large, diameter not less than one-quarter of length of head; edge of cheek armed with rather large spines; 14-15 spines in dorsal fin; colour roseate:—a Rosefish, Fig. C (see Fam. LXII, *Scorpaenidae*).

BUT IF: Eye small, diameter not more than one-fifth of length of head; edge of cheek with no spines but minutely saw-toothed; 10-11 spines in dorsal fin; colour olive-brown with reddish tinges on lower surface of head and belly:—a Red Grouper, Fig. XCVI (see Fam. LVIII, *Epinephelidae*).

Fishes with fins in a jugular position.

Section 25.

IF: Head very large, its length more than one-third of total length; mouth very wide, armed with numerous strong teeth; 3 filamentous spines on top of head, the 2 in front of eye being very long; several fleshy flaps around edge of head and on body; pectoral fin flipper-like; general appearance of a large, flat, roundish head with relatively short, narrow body:—a Monkfish, Fig. CXXIX (see Fam. LXXXI, *Lophiidae*).

BUT IF: Head not large, its length not more than one-fourth of total length; mouth either large or small; filamentous spines on top of head and fleshy flaps absent; pectoral fin of usual appearance, not flipper-like:—see Section 26.

Section 26.

IF: Head and body definitely flattened from side to side (Halibut type, Fig. XI, and not top to bottom as in Skate type, Fig. IV); both eyes on pigmented side of head, other side blind; no spiny rays:—see Section 27.

BUT IF: Body elongated, not flattened from side to side; one eye on each side of head; spiny rays present or absent:—see Section 29.

Section 27.

IF: Mouth small; posterior end of maxillary scarcely reaching front of eye; caudal fin rounded:—a member of the Flounder family, Figs. LXVIII-LXXI (see Fam. XLI, *Pleuronectidae*).

BUT IF: Mouth large; posterior end of maxillary reaching to posterior edge of eye; caudal fin rounded, forked or of another shape:—see Section 28.

Section 28.

IF: Long ventral fins not symmetrical, that on pigmented side extending from tip of isthmus to beginning of anal fin (giving the impression that these two fins are continuous) while that on white side beginning a short distance back from tip of isthmus; upper part of about 15 of anterior dorsal rays free from membrane and extensively branched (feathery in appearance); gill rakers long and over 30 in number; caudal fin rounded in outline; lateral line well arched over pectoral fin:—a Sand Flounder, Fig. LXIV (see Fam. XXXIX, *Bothidae*).

BUT IF: Ventral fins symmetrical, well separated from anal fin and tip of isthmus; anterior dorsal rays connected for their full height by membrane; gill rakers short and less than 20 in number; caudal fin rounded or of another shape; lateral line either arched or straight:—a member of the Halibut family, Figs. XI and LXV-LXVII (see Fam. XL, *Hippoglossidae*).

Section 29.

IF: Single, long dorsal fin composed of spiny rays only, this fin, as well as anal fin extending back close to caudal fin, but clearly distinguishable from latter; body elongated, snake-like:—a member of the Blenny family, Figs. CXV and CXVI (see Fam. LXXIII, *Blenniidae*).

BUT IF: 1 long dorsal fin (which may possess a few spines in posterior part) or 2 or 3 dorsal fins composed of soft rays only; caudal fin either united with or separated from both dorsal and anal fins; body elongated or rather deep:—see Section 30.

Section 30.

IF: Ventral fins rudimentary (absent in *Gymnelis viridis*), only a single dorsal and anal fin, both joined with caudal fin to form a continuous fin around tail; body elongated:—a member of the Eelpout family, Figs. CXX-CXXIV (see Fam. LXXVI, *Zoarcidae*).

BUT IF: Ventral fins well developed; 1 to 3 dorsal and 1 or 2 anal fins clearly separated from caudal fin; body more or less deep:—see Section 31.

Section 31.

IF: Long distinctly notched anal fin and 2 separate dorsal fins, the second as long as the anal fin and notched; caudal fin slightly forked; mouth armed with sharp teeth; chin barbel absent:—a Silver Hake, Fig. LXII (see Fam. XXXVII. *Merluciidae*).

BUT IF: 1 or 2 anal fins; 1 to 3 dorsal fins; caudal fin rounded or forked; teeth smaller and not so sharp; chin barbel always present:—see Section 32

Section 32.

IF: In addition to a chin barbel, 3 barbels on snout; first dorsal fin consisting of a long filamentous first ray and a series of about 40 minute rays concealed in a groove; second dorsal fin slightly longer than single anal fin; caudal fin rounded:—a Rockling, Fig. LIII (see Fam. XXXV, *Gaidropsaridae*).

BUT IF: Only barbel located on chin; first dorsal fin not concealed in a groove; number of dorsal fins from 1 to 3; single or double anal fins; caudal fin either rounded or slightly forked:—a member of the Cod family, Figs. X and LIV-LXI (see Fam. XXXVI, *Gadidae*).

Subdivision 3.

Fishes with ventral fins in an abdominal position (Salmon type, Fig. XII).

Section 1.

IF: Middle ray of caudal fin extending as a long filament about equal to one-half body length; head very long terminating in long tubular snout; scales absent:—a Trumpetfish, Fig. LXXVII (see Fam. XLIV, *Fistulariidae*).

BUT IF: Caudal filament absent; head rather short without tubular snout; scales present or absent:—see Section 2.

Section 2.

IF: Body strongly compressed from side to side, rather squarish in shape; mouth very small with strong teeth; eye located above base of pectoral fin; ventral fin represented by a short, immobile, hardly visible spine:—see Section 3.

BUT IF: Body cylindrical, not strongly compressed; mouth small or large; eye located far in front of base of pectoral fin; ventral fin normally developed consisting of at least 6 rays:—see Section 4.

Section 3.

IF: First dorsal fin consisting of 3 spines connected by a membrane; head and body covered with thick, large plate-like scales:—a Triggerfish, Fig. CXXV (see Fam. LXXVII, *Balistidae*).

BUT IF: First dorsal fin consisting of only a single, long, strong spine armed with a double series of barbs; head and body covered with such very minute scales that skin is velvety to the touch:—a Filefish, Fig. CXXVI (see Fam. LXXVIII, *Monacanthidae*).

Section 4.

IF: Both jaws elongated to form slender beak; several finlets behind both dorsal and anal fins:—a Billfish, Fig. L (see Fam. XXXII, *Scomberesocidae*).

BUT IF: Jaws not elongated; no finlets:—see Section 5.

Section 5.

IF: Luminous organs (photophores) on head and body; mouth very large:—see Section 6.

BUT IF: No luminous organs on fish; mouth large or small:—see Section 8.

Section 6.

IF: Body very thin and elevated, body depth more than half body length; high, triangular, bony ridge in front of dorsal fin consisting of several vertebral spines projecting beyond the muscle:—a Silver Hatchetfish, Fig. XL (see Fam. XXIII, *Sternoptichidae*).

BUT IF: Body elongated and rounded, body depth less than one-fourth body length; no bony ridge in front of dorsal fin:—see Section 7.

Section 7.

IF: Dorsal fin situated over anal fin, far behind ventral fins; diameter of eye not greater than one-sixth length of head:—a Small-eyed Lanternfish, Fig. XXXIX (see Fam. XXII, *Gonostomidae*).

BUT IF: Dorsal fin situated in front of anal fin, about over ventral fins; diameter of eye not less than one-third length of head:—a member of the Large-eyed Lanternfish family, Figs. XLVI and XLVII (see Fam. XXIX, *Myctophidae*).

Section 8.

IF: A single dorsal fin:—see Section 9.

BUT IF: 2 dorsal fins, second of which may be an adipose fin (shown in black on figures):—see Section 13.

Section 9.

IF: Pectoral fin enlarged into a kind of wing, its length at least one-half body length:—a Flyingfish, Fig. LI (see Fam. XXXIII, *Exocoetidae*).

BUT IF: Pectoral fin not wing-like, its length less than one-fifth body length:—see Section 10.

Section 10.

IF: Head covered with scales; caudal fin rounded, not forked:—a Mummichog, Fig. XLIX (see Fam. XXXI, *Cyprinodontidae*).

BUT IF: Head having no scales; caudal fin deeply forked:—see Section 11.

Section 11.

IF: Last ray of dorsal fin extending beyond fin membrane as a long filament; scales larger than eye:—a Tarpon, Fig. XXVI (see Fam. XIV, *Megalopidae*).

BUT IF: No long filament in dorsal fin; scales smaller than eye:—see Section 12.

Section 12.

IF: Anal fin situated behind posterior end of base of dorsal fin; posterior end of maxillary scarcely reaching posterior edge of eye orbit:—a member of the Herring family, Figs. XXVII-XXX (see Fam XV *Clupeidae*).

BUT IF: Anal fin situated below dorsal fin, maxillary extending far behind posterior edge of eye:—an Anchovy, Fig. XXXI (see Fam. XVI, *Engraulidae*).

Section 13.

IF: 2 dorsal fins, second possessing rays:—see Section 14.

BUT IF: 2 dorsal fins, the second an adipose fin (shown in black on figures) without rays (Salmon type, Fig. XII):—see Section 15.

Section 14.

IF: Anal fin short with no more than 10 soft rays:—a Mullet, Fig. LXXIX (see Fam. XLVI, *Mugilidae*).

BUT IF: Anal fin long with more than 15 soft rays:—a Silverside, Fig. LXXVIII (see Fam. XLV, *Atherinidae*).

Section 15.

IF: First dorsal fin very high, its length more than one-half body length:—a Lancetfish, Fig. XLVIII (see Fam. XXX, *Alepisauridae*).

BUT IF: First dorsal fin not high, its length not more than one-fifth body length:—see Section 16.

Section 16.

IF: Posterior end of maxillary hardly extending to below front of eye:—see Section 17.

BUT IF: Maxillary extending at least to below middle of eye:—see Section 19.

Section 17.

IF: Eye small, its diameter about equal to one-fifth head length; ventral fin situated below middle of base of dorsal fin:—a Whitefish, Fig. XXXIV (see Fam. XVIII, *Coregonidae*).

BUT IF: Eye large, its diameter not less than about one-third head length; ventral fin situated under rear end of base of dorsal fin:—see Section 18.

Section 18.

IF: Diameter of eye more than one-third length of head; only 3 or 4 branchiostegal rays:—a Large-eyed Argentine, Fig. XXXVIII (see Fam. XXI, *Microstomidae*).

BUT IF: Diameter of eye less than one-third length of head; 6 to 8 branchiostegal rays:—a Small-eyed Argentine, Fig. XXXVII (see Fam. XX, *Argentinidae*).

Section 19.

IF: Anal fin having less than 10 branched rays; ventral fin situated behind middle of base of dorsal fin:—a member of the Salmon family, Figs. XII and XXXIII (see Fam. XVII, *Salmonidae*).

BUT IF: Anal fin having 14 or more branched rays; ventral fin situated in front of middle of base of dorsal fin:—a member of the Smelt family, Figs. XXXV and XXXVI (see Fam. XIX, *Osmeridae*).

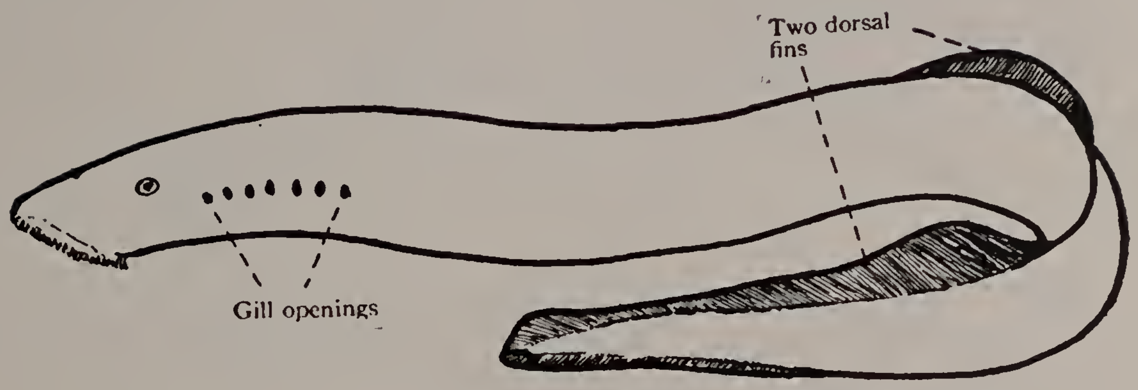

Fig. II—Lamprey (*Petromyzon marinus*). Type of fish without paired fins.

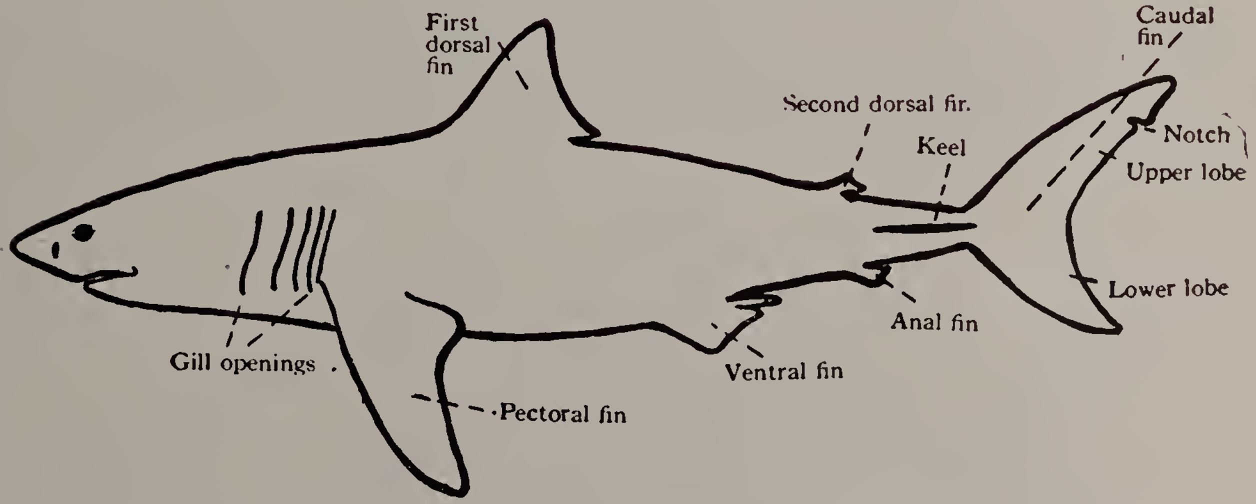

Fig. III—Man-eater Shark (*Carcharodon carcharias*). Shark type.

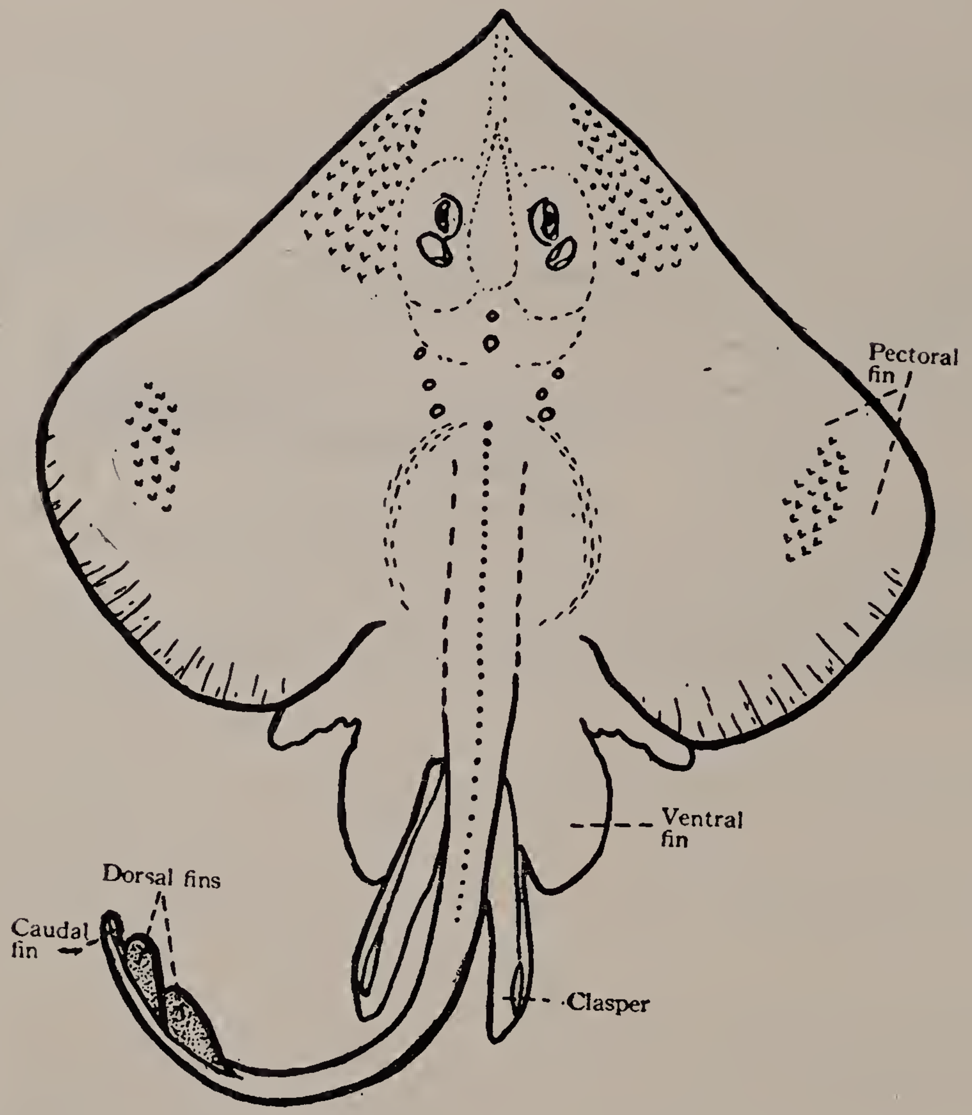

Fig. IV—Smooth Skate (*Raja senta*) Tvpe of Skate; dorsal view.

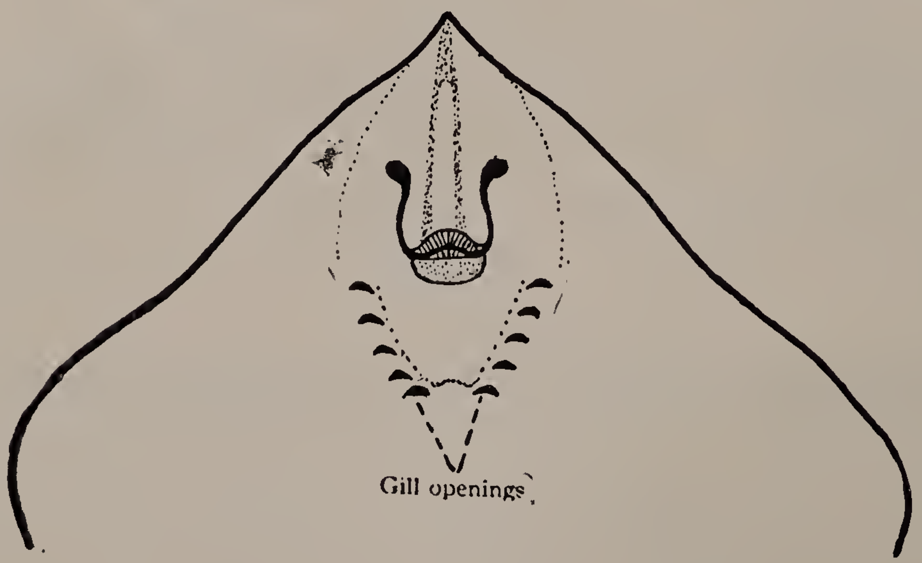

Fig. V—Smooth Skate (*Raja senta*); ventral view.

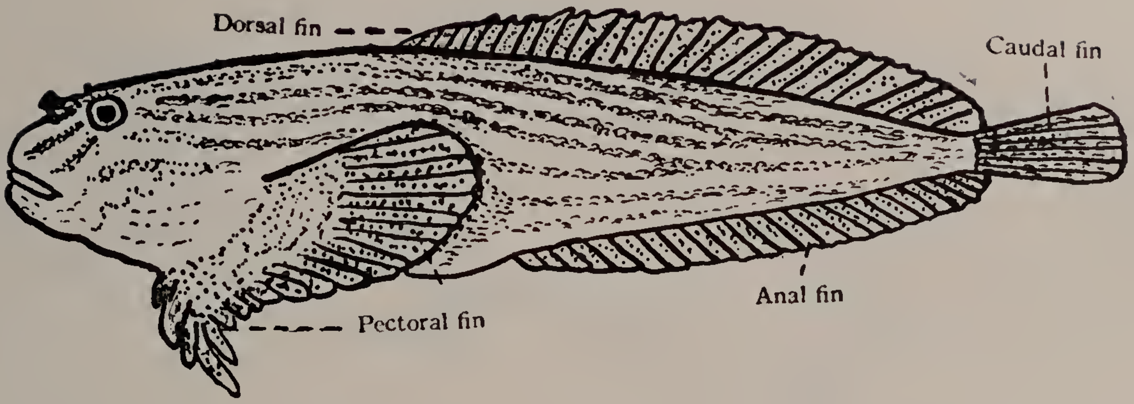

Fig. VI—Striped Sea Snail (*Liparis liparis*). Type of fish with ventral fins modified into a sucking disc; lateral view.

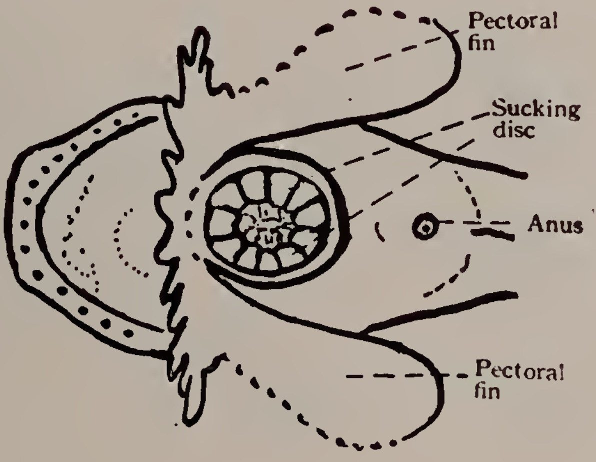

Fig. VII—Striped Sea Snail (*Liparis liparis*), ventral view.

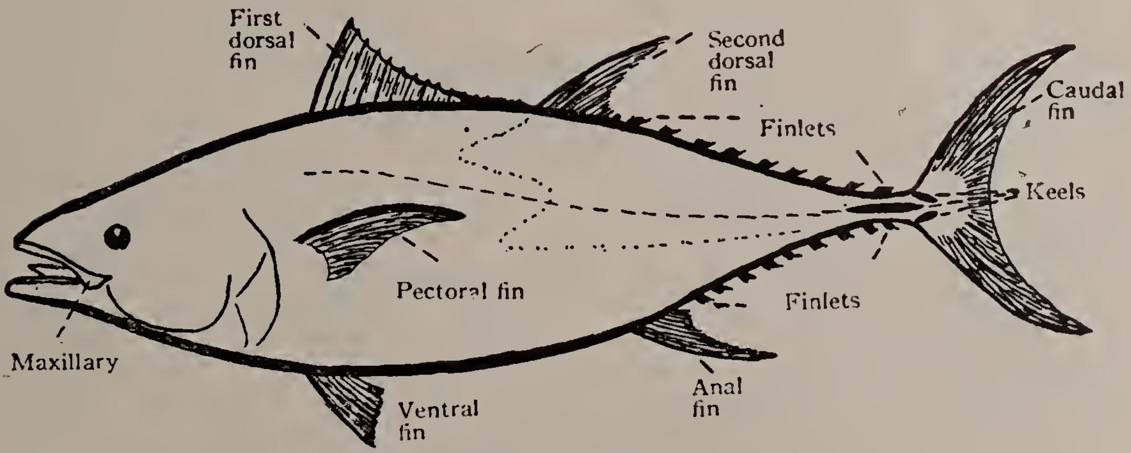

Fig. VIII—Tuna (*Thunnus thynnus*). Type of fish with ventral fins in thoracic position and with finlets.

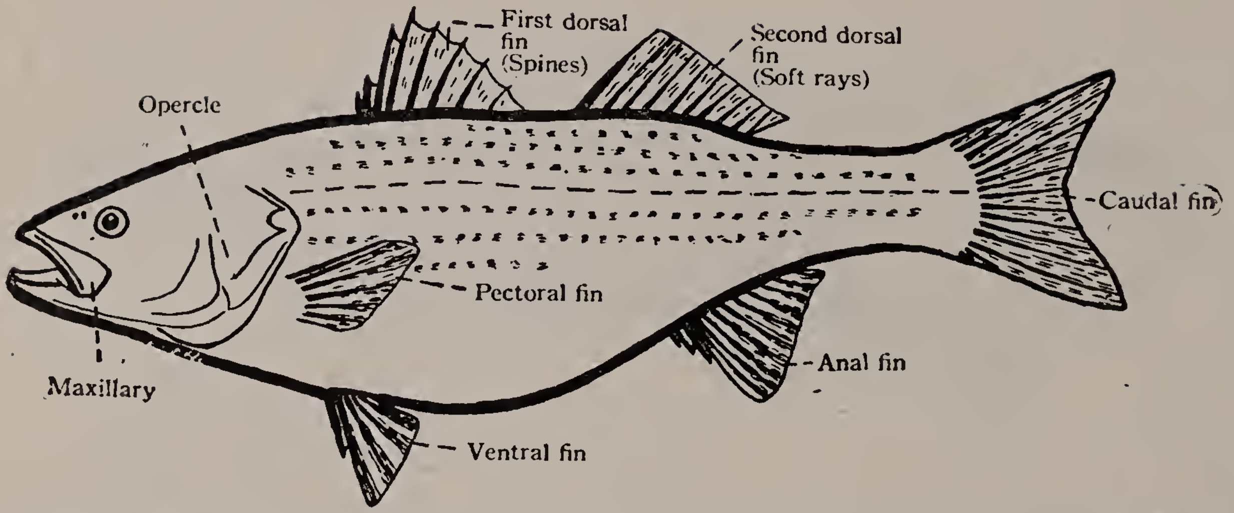

Fig. IX—Striped Bass (*Roccus lineatus*). Type of fish with ventral fins in a thoracic position, and with two dorsal fins, the first of which consists of strong spines only.

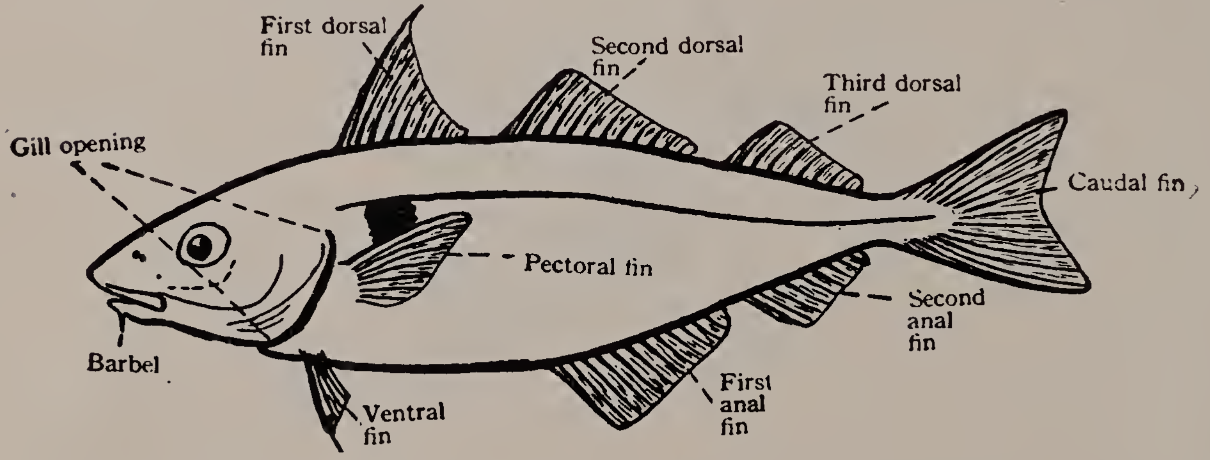

Fig. X—Haddock (*Melanogrammus aeglefinus*). Type of fish with ventral fins in a jugular position, and with three dorsal and two anal fins which, as well as the remaining fins, consist only of soft rays.

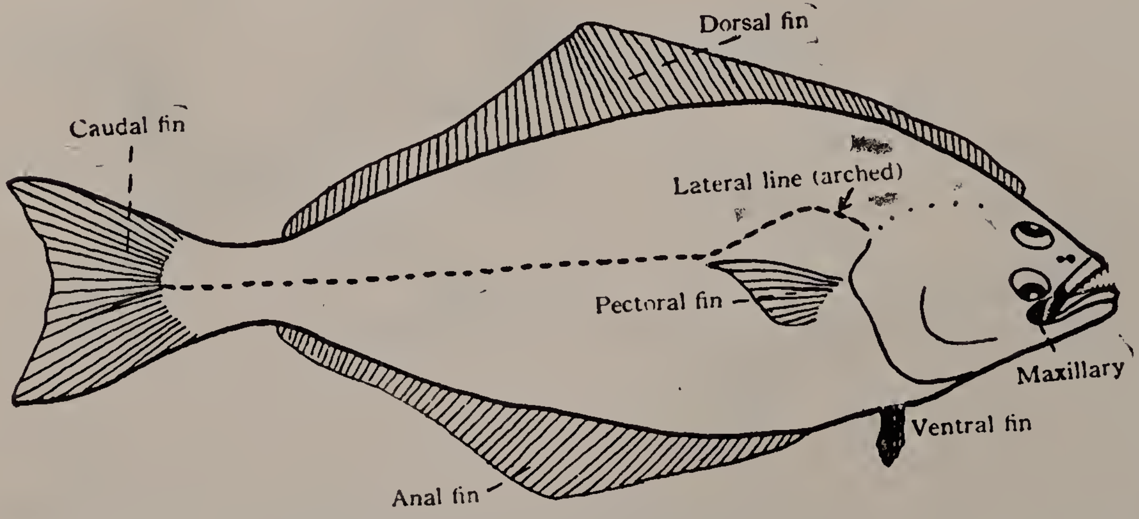

Fig. XI—Halibut (*Hippoglossus hippoglossus*). Type of right-handed Flatfish with ventral fins in a jugular position.

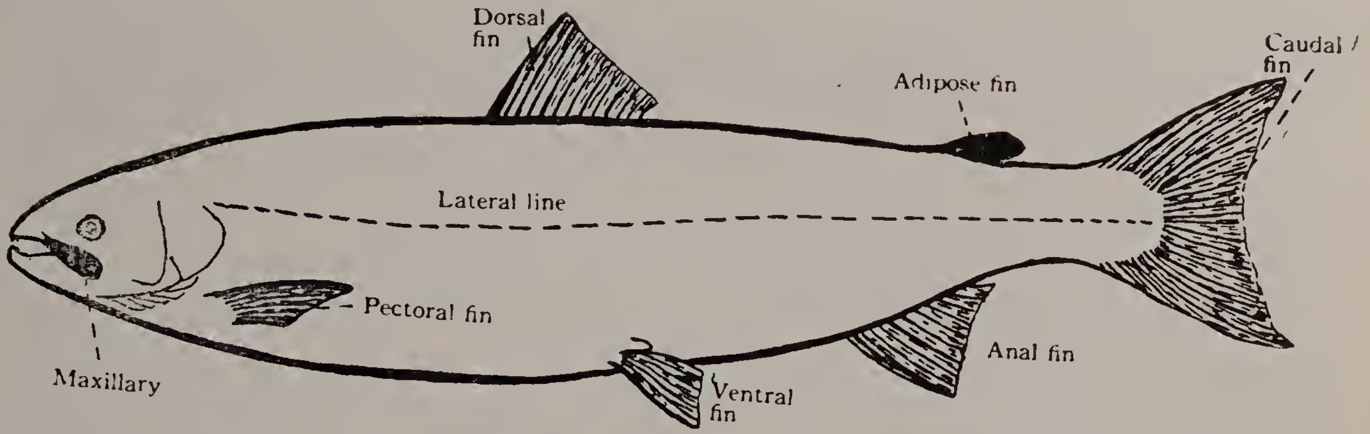

Fig. XII—Salmon (*Salmo salar*). Type of fish with ventral fins in an abdominal position, and with an adipose fin.

DESCRIPTION OF FISHES.

In our description, we follow, on the whole, the systematic arrangement of Jordan, Evermann and Clark[13]. The systematic description will not be mentioned here, since it has already been given concisely in the Key. However, brief remarks on seasonal occurrence, distribution, economic importance and size will be made for each species. In some cases, interesting points in the biology of the fishes will be given also.

For the reader's convenience, lengths and weights have been expressed in the English system. The information on the size of the fishes has been taken mainly from Bigelow and Welsh[3], while the data on the vertical distribution of deep water forms have been obtained principally from Bean[14] and Goode and Bean[5].

All fishes listed herein may be divided into two wide groups. One consists of species which are found throughout the whole year in our region (e. g., Cod and Haddock), and may be called "permanent residents", while the other group embraces fishes occurring for a relatively short period of time, or only occasionally found, within our waters, "seasonal visitors." Some species of the latter group (e. g., Tuna and Swordfish) visit our shores regularly every year, others only occasionally. Southern species are found during the warmest months (e. g. Hardtail), whereas northern fishes (e. g., Greenland Shark) are caught in our region during the coolest months.

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[13] Jordan, Evermann and Clark. *Rept. U. S. Comm. Fish.*, **1928**, Pt. 2, 670 pp. (1930).

[14] Bean. *Proc. U. S. Nat. Mus.*, **3**, 75-116 (1881).

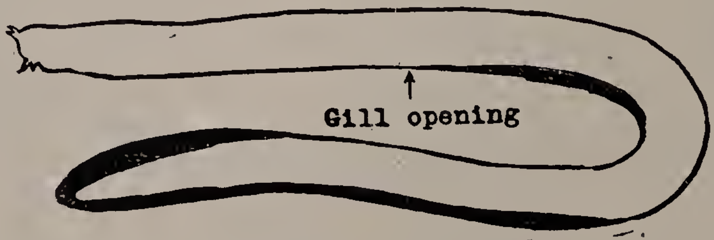
The Nova Scotian region under description is divided physiographically into two parts, the outer or Atlantic coast and the inner or Bay of Fundy area. In each part, the relatively shallow coastal waters (not exceeding 25 fathoms) are inhabited by certain fishes, while the deeper offshore areas are frequented, as a rule, by other species. Numerous banks (off the outer coast), with water from 30 to 80 fathoms deep, are populated by a number of species, some of which are found only on these banks. The deepest water (150 to 350 fathoms) is found in the gullies between the banks. The bank area, as a whole, is bounded by the edge of the Continental Slope where much greater depths are encountered. The distribution of each species is given according to these physiographical areas.

To designate differences in abundance of the various species, such terms as the following have been used: very rare or rare, uncommon, common and very common. Among the fishes described by the last two terms are many of economic importance. The data concerning the quantity caught and value of these species are taken from the *Fisheries Statistics of Canada*. The yearly averages for the ten year period, 1924 to 1933 inclusive, have been calculated and used in this paper.

The fishes marked with an asterisk (*) either live in salt water, spending only part of the time in fresh water for the purpose of spawning (anadromous fishes, e. g., Salmon, Shad, etc.) or grow up in fresh water, returning to the sea for spawning (e. g., Eel).

I. HAGFISH FAMILY, *MYXINIDAE.*

Hagfish,
Myxine glutinosa
Linnaeus 1758
(Fig. XIII).



Rather common on Nova Scotian banks and in the Bay of Fundy in depths of about 20 to 50 fathoms, but may descend occasionally to 500 fathoms. Without economic importance. Up to 18 inches in length. Parasitic in behaviour, being found inside the bodies of other fishes and even in human corpses.

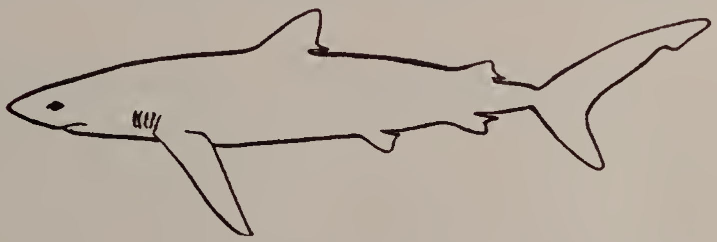
II. LAMPREY FAMILY, *PETROMYZONIDAE.*

***Sea Lamprey,** *Petromyzon marinus* Linnaeus 1758 (Fig. II).

Not uncommon, but very seldom caught in the sea (a few records from Brown's Bank). Usually captured in estuaries during early summer. At present without economic importance in our region; however, in Europe it is highly reputed. Historians tell us that Henry I of England died of a surfeit of this great delicacy. Up to 3 feet in length. Semi-parasitic, living on the blood and flesh of other fishes. Dies after spawning.

III. GREY SHARK FAMILY, *CARCHARIIDAE.*

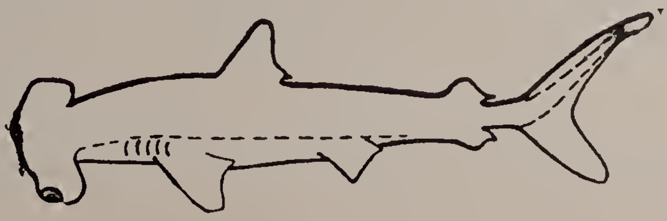
Blue Shark,
Prionace glauca
(Linnaeus) 1758
(Fig. XIV).



This pelagic fish not an uncommon summer visitor on Nova Scotian banks and sometimes even in the inshore waters of the outer coast. Nuisance to fishermen through destroying gear and catches. Maximum length 12 feet. Very common in southern waters. Skin of this species, as well as other sharks, sometimes used in making ladies' purses, shoes, etc.

IV. HAMMERHEAD SHARK FAMILY, *SPHYRNIDAE.*

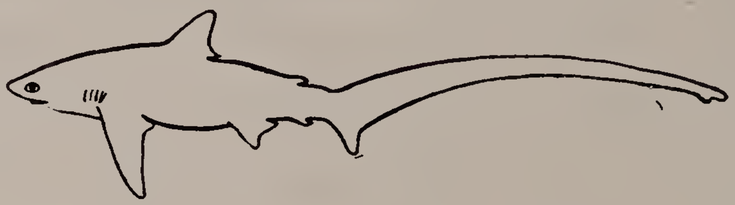
Hammerhead Shark,
Sphyrna zygaena
(Linnaeus) 1758
(Fig. XV).



This southern form very rare, only young individuals occasionally straying into the Atlantic waters of Nova Scotia during the warmest seasons. Vladykov[15] reported finding a specimen 20½ inches long off Herring Cove, Halifax Harbour, September, 1932. Maximum length 17 feet in southern waters. Without economic importance. All our Sharks may be considered as pelagic fishes. However, some of them descend to a considerable depth.

V. THRESHER SHARK FAMILY. *ALOPIIDAE.*

Thresher Shark,
Alopes vulpes
(Bonnaterre) 1788
(Fig. XVI).



Not uncommon during summer months on the Atlantic banks and in the Bay of Fundy. Without economic importance. Length up to about 20 feet. Very destructive to Herring and Mackerel.

VI. MACKEREL SHARK FAMILY. *ISURIDAE.*

Key for genera.

IF: Teeth broad, triangular, saw-toothed on edges (Fig. XVIIA), without lateral cusps; pectoral fin one and a half to two times as long as height of first dorsal fin:—a Man-eater Shark (*Carcharodon*), Fig. III.

BUT IF: Teeth narrow, pointed, without saw-toothed edges (Fig. XVIIB) but with lateral cusps; pectoral fin only slightly longer than height of first dorsal:—a Mackerel Shark (*Isurus*).

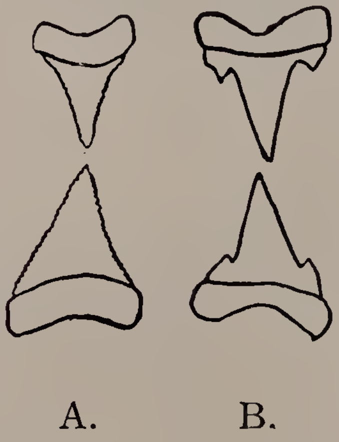


Fig. XVII—Types of teeth in two genera of the Mackerel Shark family; A.—*Carcharodon*; B.—*Isurus*.

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[15] Vladykov. *Proc. N. S. Inst. Sci.*, **19**, 1-8 (1935).

Mackerel Shark, *Isurus nasus* (Bonnaterre) 1788.

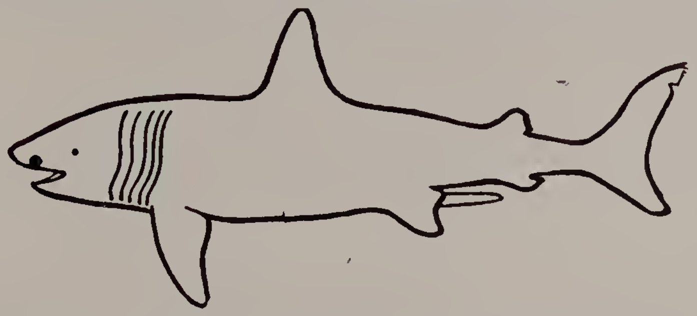
Not an uncommon summer visitor in the bays of the Atlantic coast. Occasionally caught in Mackerel traps and nets. Up to 12 feet in length. Name derived from its habit of feeding on Mackerel. Without economic importance.

Man-eater Shark, *Carcharodon carcharias* (Linnaeus) 1758 (Fig. III).

Not uncommon along the Atlantic coast and in the Bay of Fundy (Piers[16b], pp. 196-198). Without economic importance. Maximum length about 40 feet[17]. Dangerous to man, occasionally attacking fishermen in their boats.

VII. BASKING SHARK FAMILY, *CETORHINIDAE.*

Basking Shark, *Cetorhinus maximus* (Gunner) 1765 (Fig. XVIII).



Although there are no positive records of the capture of this Arctic species in the Nova Scotian area, no doubt it occurs here. Without economic importance. The largest of our fishes, maximum size at least 40 feet[18]. Sluggish in its movements, not dangerous to man. Feeds mainly on same food as Herring, such as smaller crustaceans.

[16] Piers. Numerous notes published in the Annual Reports of the Provincial Museum (Halifax) and several articles in *Proc. Trans. N. S. Inst. Sci.*, those of particular interest: (a) Vol. **10**, Pt. I., 110-111 (1903); (b) *ibid.* **18**, Pt. 3, 192-203 (1934).

[17] According to the information of V. D. Vladykov, a 37 foot Man-eater Shark was found dead in a Herring weir on White Head Island (near Grand Manan) in the middle of June, 1930. From the liver 210 gallons of oil were obtained. Another idea of the huge size of this species may be obtained from the observation that a 30 foot Man-eater Shark had a young Sea Lion, weighing about 100 pounds, in its stomach (Jordan and Evermann) *loc. cit.*

[18] Perley, ("*Descriptive Catalogue* (*in part*) *of the Fishes of New Brunswick and Nova Scotia,*" 2nd Ed. **1852,** 50 pp.), gave an interesting account of a large Basking Shark caught in August, 1851 off Musquash Harbour in the Bay of Fundy. It was 40 feet in length, head 5 feet across, mouth 3 feet wide and the liver yielded 320 gallons of oil.

VIII. DOGFISH FAMILY, *SQUALIDAE.*

Key for genera.

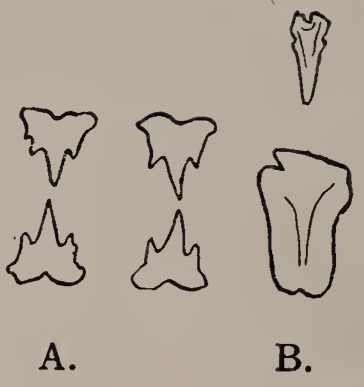


Fig. XIX—Types of teeth in two genera of the Dogfish family; A.—*Centroscyllium;* B.—*Centroscymnus.*

Section 1.

IF: Spines in front of dorsal fins very short; upper lobe of caudal fin notched; teeth on upper jaw different from those on lower jaw (Fig. XIXB):—Portuguese Dogfish (*Centroscymnus*).

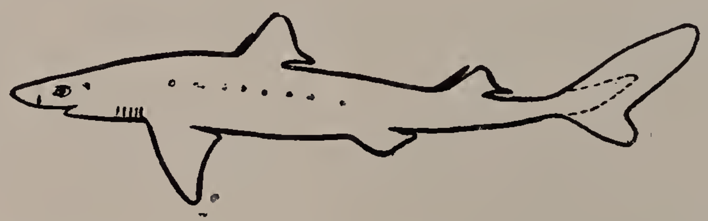
BUT IF: Spines in front of dorsal fins long; notch on upper lobe of caudal fin present or absent; teeth alike on both jaws:—see Section 2.

Section 2.

IF: Teeth short without pronounced central cusp; no notch present on upper lobe of caudal fin; pectoral fin rather long and triangular:—a Spiny Dogfish (*Squalus*), Fig. XX.

BUT IF: Teeth rather long with well developed central cusp (Fig. XIXA); notch on upper lobe of caudal fin present, pectoral fin short and rounded: —a Black Dogfish (*Centroscyllium*), Fig. XXI.

Spiny Dogfish,
Squalis acanthias
Linnaeus 1758
(Fig. XX).

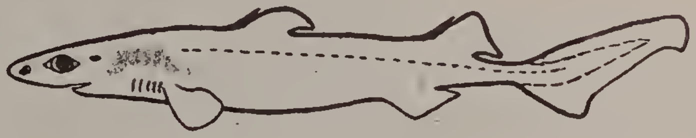


Very common throughout the whole region, particularly abundant in inshore waters during the summer, withdrawing in winter months offshore and southward. Found usually from surface down to about 50 fathoms. At present of slight economic importance, only oil from the liver being used. This fish, however, can be utilized for human consumption. Dogfish are a great nuisance to line and net fishermen through destroying gear and catches. Up to 4 feet in length.

Portuguese Dogfish, *Centroscymnus coelolepis* Bocage and Capello 1864.

Rather rare, being reported by Bean[14] from Quereau Bank at a depth of 180 to 260 fathoms and, according to Bigelow and Schroeder[4] (p. 18), from LeHave Bank. Without economic importance. Up to 4 feet in length.

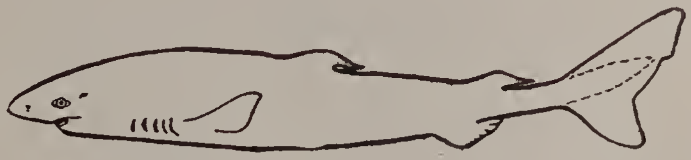
Black Dogfish,
Centroscyllium fabricii
(Reinhardt) 1828
(Fig. XXI).



Not uncommon on the Nova Scotian banks in rather deep water (200 to 250 fathoms), being caught on Halibut trawl. Without economic importance. About the same size as the Portuguese Dogfish.

IX. NURSE SHARK FAMILY, *SOMNIOSIDAE.*

Greenland Shark,
Somniosus microcephalus
(Bloch and Schneider) 1801
(Fig. XXII).



This rather northern form very rare. Jones[19] has reported the only capture of this species in our region, namely a specimen 11¼ feet long off Halifax Harbour in February 1863. No other captures recorded since that time. Up to 18 feet in length.

X. SKATE FAMILY, *RAJIDAE.*

The distinction between the different species of Skates is a difficult systematic problem. Therefore, in this paper, only a tentative key for their identification is given, which is based chiefly on the data of Garman[6] (pp. 337-343) and Bigelow and Schroeder[4]. In this key, peculiar male characters, such as claspers and rows of spines on each pectoral fin, are not especially mentioned, hence in the near future a more detailed systematic account of our Skates will be published. The Skates, considering only their flattened body and the

[19] Jones. *Proc. Trans. N. S. Inst. Nat. Sci.*, 5, Pt. I, 87-97 (1882).

presence of both eyes on the same surface, might be confused with the Flatfishes. However, the nature of the flattening in the two groups of fishes is entirely different. The pigmented surface, bearing both eyes in the Skate, is really the back, not the right or left side of the fish, as in the case of Flatfishes. (For description of the latter group, see families XXXVIII-XL). The Skates are easily distinguished by the presence of the mouth and five pairs of gill slits on the lower or ventral surface, and a long tail (Figs. IV and V).

Key for species of genus *Rajia.*

Section 1.

IF: Snout pronouncedly elongated and quite pointed; dorsal surface of fish almost naked; small spines developed on tip of snout and along front margin of body; only 1 series of small spines located along middle of tail extending slightly onto back:—a Barndoor Skate (*R. laevis*).

BUT IF: Snout not pronouncedly elongated; dorsal surface of fish covered with large or small spines; 1 or 2 series of spines along middle of tail and back:—see Section 2.

Section 2.

IF: Front outline of body rounded; 1 main series of small spines located along each side of dorsal mid-line of body and tail, leaving mid-line itself naked:—see Section 3.

BUT IF: Front outline of body more angular than rounded; 1 main series of spines located on dorsal mid-line of the body and tail:—see Section 4.

Section 3.

IF: 38 to 60 rows of teeth on each jaw:—a Little Skate (*R. erinacea*).

BUT IF: Teeth more numerous, varying from 66 to 140 rows on each jaw:—an Eyed Skate (*R. diaphanes*).

Section 4.

IF: Snout pointed; single series of small spines (over 30 in number) on dorsal mid-line extending over whole back but only onto anterior part of tail; tail length about equal to that of body; on the snout a parchment-like, triangular, transparent space:—a Smooth Skate (*R. senta*) Fig. IV.

BUT IF: Snout not noticeably pointed; single series of large spines on dorsal mid-line less than 20 in number; tail length about one-half that of body; no triangular, transparent space on snout:—see Section 5.

Section 5.

IF: Dorsal surface in addition to dorsal mid-line thickly covered with large spines; less than 45 teeth in each jaw:—a Thorny Skate (*R. scabrata*).

BUT IF: Dorsal surface in addition to dorsal mid-line covered with small spines; about 60 teeth on each jaw:—a Deepwater Thorny Skate (*R. granulata*).

Little Skate, *Raja erinacea* Mitchill 1825.

Very common throughout the whole region, in coastal waters during summer months and deeper waters (down to 50 fathoms) in the winter. Of slight economic importance, used for making fish meal. Annual catch of all species of Skates in our region amounts to about 426,000 pounds, in value $13,000. Up to 2 feet in length. This, as other Skates, is a bottom fish.

Eyed Skate, *R. diaphanes* Mitchill 1803.

Similar to the previous species in abundance, distribution and economic importance. Up to 3 feet in length.

Thorny Skate, *R. scabrata* Garman 1913.

Very common over whole region. Usually found in deeper water than the two previous species. Maximum length 3 feet.

Smooth Skate, *R. senta* Garman 1885 (Fig. IV).

Rather uncommon. Previously known from Le Have Bank (80 to 100 fathoms). Our specimens off Emerald Bank (50 to 60 fathoms). Up to 2 feet in length.

Barndoor Skate, *R. laevis* Mitchill 1817.

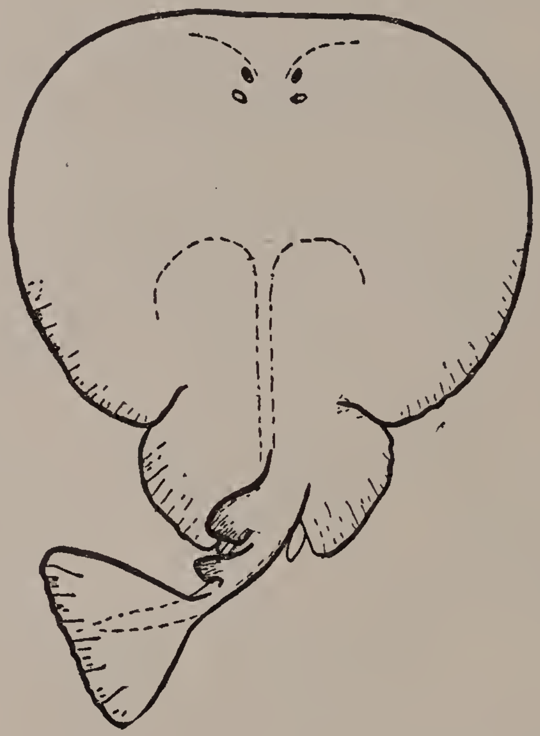
Common throughout the whole region from the shore out to a depth of 100 fathoms. The largest of our Skates, maximum length about 6 feet.

Deepwater Thorny Skate, *R. granulata* Gill 1879.

This rather deep water species (taken from 200 fathoms) very rare, only odd specimens known off Le Have Bank (Goode and Bean[5], p. 29) and continental edge off Halifax (Bigelow and Schroeder[4], p. 30).

XI. ELECTRIC RAY FAMILY, *TORPEDINIDAE.*

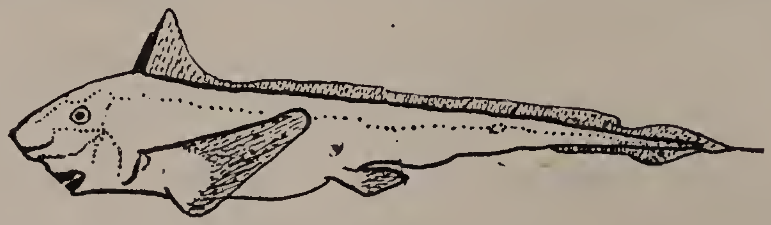
Electric Ray,
Narcacion nobilianus
(Bonaparte) 1832
(Fig. XXIII).



This southern form very rare. Bigelow and Schroeder[4] (p. 36) mentioned the capture of a specimen on Le Have Bank. We have verbal information on a specimen, presumably of this species, taken off Fox Point, St. Margaret Bay, about twenty years ago. Up to 5 feet in length. This fish is capable of giving an electric shock of considerable strength.

XII. CHIMAERA FAMILY, *CHIMAERIDAE.*

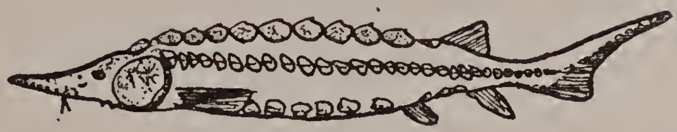
Chimaera,
Chimaera monstrosa
Linnaeus 1758
(Fig. XXIV).



Not uncommon on Nova Scotian banks, being reported from a number of places in 160 to 350 fathoms by Bean[14] (p. 114) and Goode and Bean[5] (p. 32). Maximum length about 4 feet.

XIII. STURGEON FAMILY, *ACIPENSERIDAE.*

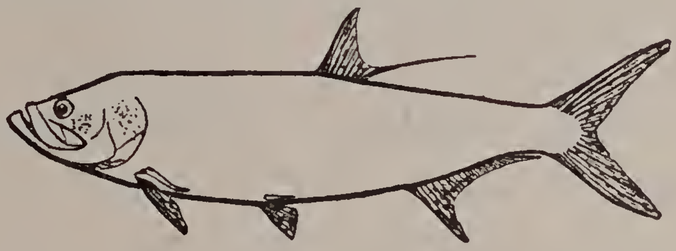
***Sturgeon,**
Acipenser sturio
Linnaeus 1758
(Fig. XXV).



Rather common over whole area, being taken near estuaries, chiefly early in summer. Of slight economic importance Annual catch reported as 3,500 pounds, value $236. The eggs of this, as well as other species of Sturgeon, are used in making caviar.

XIV. TARPON FAMILY, *MEGALOPIDAE.*

Tarpon,
Tarpon atlanticus
(Cuvier and Valenciennes) 1884
(Fig. XXVI).



This southern form very rare, only two positive records of capture are known, one off Isaac's Harbour, (Halkett,[20] p. 45) and one from Harrigan Cove which was 5⅓ feet in length[21]. Maximum length 8 feet and about 400 pounds in weight.

XV. HERRING FAMILY, *CLUPEIDAE.*

Key for genera.

Section 1.

IF: Body elongated, depth not more than one-fourth of body length; belly rounded, not very sharp or saw-toothed on edge; small patch of teeth on vomer:—a Herring (*Clupea*), Fig. XXVII.

BUT IF: Body rather deep, depth about one-third of body length; belly narrow, V-shaped, sharp and strongly saw-toothed; no teeth on vomer:—see Section 2.

Section 2.

IF: Head large, length about one-third of body length; diameter of eye about one-seventh of head length; ventral fin located slightly in front of dorsal fin; posterior edge of scales possessing several radial keels:—a Menhaden (*Brevoortia*) Fig. XXX.

[20] Halkett. "*Check list of the fishes of the Dominion of Canada and Newfoundland.*" Ottawa, **1913,** 138 pp.

[21] This specimen was speared in the eel grass on September 6, 1906, and it is at present exhibited in the Provincial Museum, Halifax, (No. 3034).

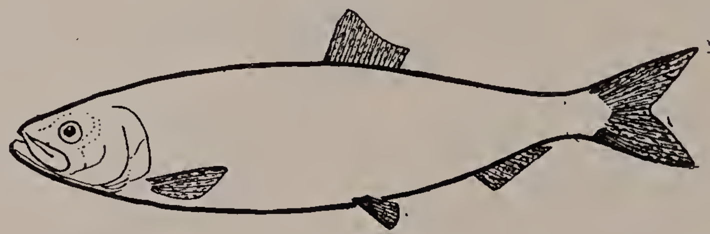
BUT IF: Head small, length at least one-fourth of body length; diameter of eye not less than one-fifth of head length; ventral fin located slightly behind front of dorsal fin; posterior edge of scales rounded and smooth without radial keels:—see Section 3.

Section 3.

IF: 2 wing-like folds of skin present at base of caudal fin, each covered with one elongated scale (black in the figure); upper jaw distinctly notched in front; point of junction of lower jaw with skull under posterior edge of eye:—a Shad (*Alosa*), Fig. XXIX.

BUT IF: No wing-like folds with elongated scales at base of caudal fin; upper jaw only slightly notched; junction of lower jaw with skull under middle of eye:—an Alewife (*Pomolobus*), Fig. XXVIII.

Herring,
Clupea harengus
Linnaeus 1758
(Fig. XXVII).



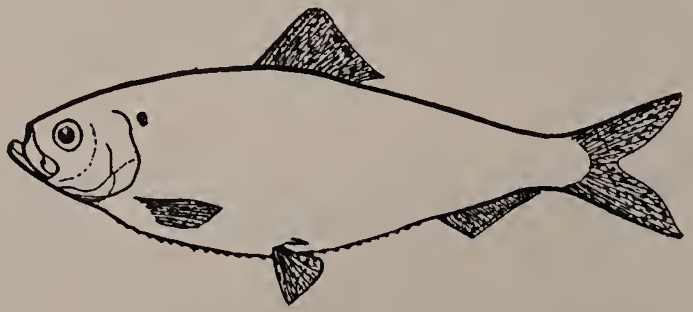
Very common throughout the whole region, particularly abundant in inshore waters (except in winter). One of the most important commercial fishes; annual catch about 21,250,000 pounds, in value $420,000. Canadian "Sardines" are made from young Herring. Maximum length about 17 inches.

Key for species of genus *Pomolobus*.

IF: Diameter of eye about equal to length of snout; body about three and a half times as long as deep; lining (peritoneum) of belly cavity black; colour of back bluish-green:—a Blueback (*P. aestivalis*).

BUT IF: Diameter of eye greater than length of snout; body only about three times as long as deep; lining (peritoneum) of belly cavity pale; colour of back greyish-green:—a Gaspereau (*P. pseudoharengus*).

***Gaspereau,**
Pomolobus
pseudoharengus
(Wilson) 1811
(Fig. XXVIII).

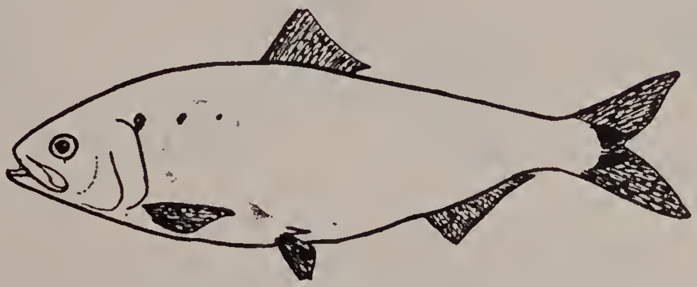


Very common over the whole region, main catches being made in estuaries and rivers in spring. Of considerable economic importance, annual catch about 2,143,000 pounds, in value $30,400. Up to about 1 foot in length.

***Blueback,** *P. aestivalis* (Mitchill) 1815.

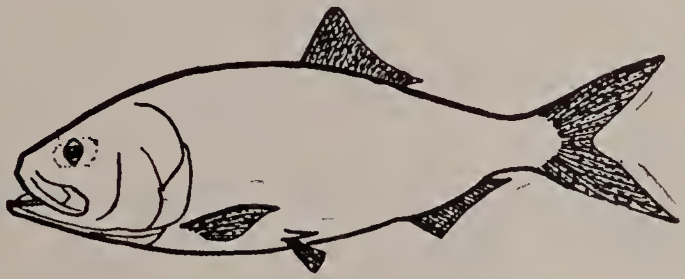
Rather uncommon, being more abundant on the Bay of Fundy side of Nova Scotia. Of slight economic importance. About the same size as the Gaspereau.

***Shad,**
Alosa sapidissima
(Wilson) 1811
(Fig. XXIX).



Common throughout the whole region, main catches being made in the spring near estuaries and in the autumn in inshore waters. More abundant on the Bay of Fundy side of Nova Scotia.[22] Of considerable economic importance, about 80,000 pounds, valued at $8,600, being taken annually. Length up to about 2½ feet, and as heavy as 14 pounds in weight.

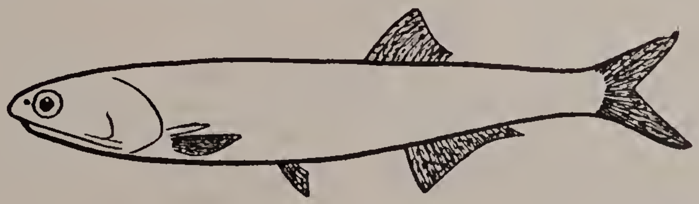
Menhaden,
Brevoortia tyrannus
(Latrobe) 1802
(Fig. XXX).



This southern form rather rare, being known only from St. Mary Bay (Bigelow and Welsh[3], p. 120) on the western coast of Nova Scotia. Up to about 15 inches in length.

XVI. ANCHOVY FAMILY, *ENGRAULIDAE.*

Striped Anchovy,
Anchoviella epsetus
(Bonnaterre) 1788
(Fig. XXXI).



This southern fish very rare, being caught for the first time in our region in 1931, in Bedford Basin, Halifax Harbour (Vladykov[15]). Up to 6 inches in length.

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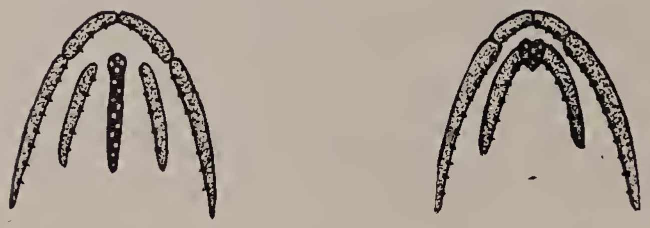
[22] Leim (*Contr. Can. Biol. N. S., II,* 163-184, 1924) published an important contribution on the life history of this species.

XVII. SALMON FAMILY, *SALMONIDAE*.

Key for genera.



A.—*Salmo*. B.—*Salvelinus*.

Fig. XXXII—Types of vomers in two genera of the Salmon family.

IF: Posterior end of maxillary (shown in black in figures) scarcely reaching posterior edge of eye; vomer long, extending backwards slightly beyond posterior end of palatines; possessing teeth along its full length (in old specimens these teeth may be wanting); teeth on front part of vomer separated on either side by a narrow space from palatine teeth (Fig. XXXII A); scales large, less than 125 along lateral line; caudal fin slightly forked; no black marbling on dorsal and anal fins:—a Salmon (*Salmo*), Fig. XII.

BUT IF: Maxillary reaching far behind posterior edge of eye; vomer very short, triangular in shape, practically not extending backwards at all between palatines; teeth on vomer not separated from palatine teeth (Fig. XXXII B); scales small, about 200 along lateral line; caudal fin usually squarish; black marbling on dorsal and anal fins:—a Trout (*Salvelinus*), Fig. XXXIII.

***Atlantic Salmon,** *Salmo salar* Linnaeus 1758 (Fig. XII).

Common throughout the whole region in coastal waters. Main fisheries concentrated near estuaries during summer months. One of the most important commercial fishes, annual catch about 1,000,000 pounds, valued at $175,000, and of great sport value also. Scarcely ever reaches 50 pounds in weight in our region, but in the Scandinavian Peninsula and in northern Russia Salmon reach a much greater size. The largest recent record was of a 139 pound (63 kg.) fish caught July, 1928, in the Tana River between Norway and Finland[23]. In certain Nova Scotian lakes a landlocked form of Salmon is found, locally known as "Grayling."

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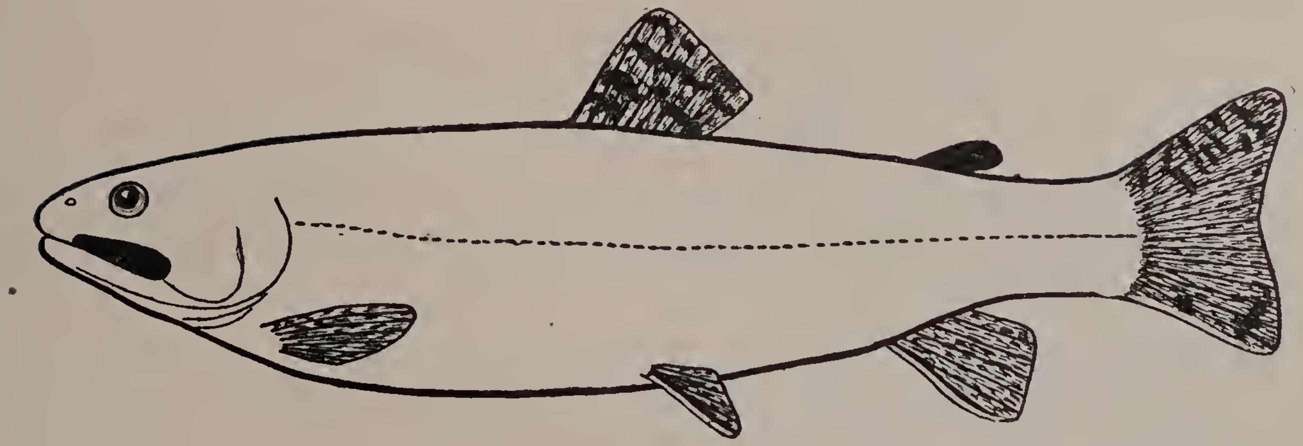
[23] This record was published in "*Fiskeritidiskrift for Finland,*" **1930**, p. 75, according to Berg "*Les poissons des eaux douces de l' U.R.S.S. et des pays limitrophes*", **1932**, p. 135, footnote.

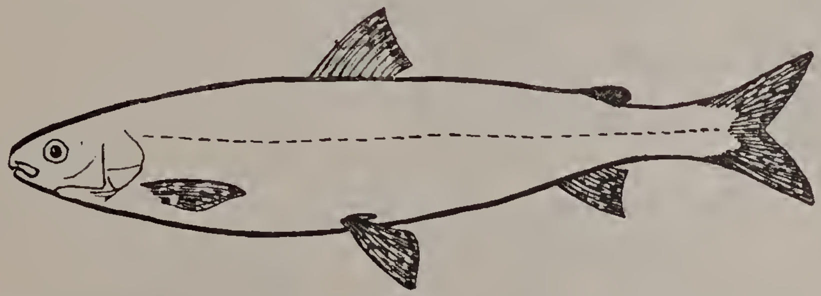


***Sea Trout,** *Salvelinus fontinalis* (Mitchill) 1815 (Fig. XXXIII).

Very common over the whole region in the coastal waters. Economically very important as one of the best sport fishes. Caught in estuaries, seldom in salt water. Scarcely ever reaches 6 pounds in weight. Its landlocked form, so-called "Brook Trout" or "Lake Trout[24]" is found in practically all streams, rivers and lakes of this province.

XVIII. WHITEFISH FAMILY, *COREGONIDAE.*

***Round Whitefish,**
Prosopium quadrilaterale
(Richardson) 1832[25]
(Fig. XXXIV).



Rare in our region, only two specimens were caught at the mouth of the Sissibou River, St. Mary Bay, 1919, (Huntsman[26], p. 59). Probably this species has been artificially introduced into our region[27].

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[24] The name "Lake Trout" is also applied to another much larger species of Trout (*Cristivomer namaycush*). The latter fish, found in certain lakes of Nova Scotia, is exclusively a freshwater species and is more often called "Grey Trout" or "Togue" in this Province.

[25] Concerning this specific name, Huntsman (see footnote 26) stated: "two specimens of a *Coregonus* (were) doubtfully identified as this species by Dr. Cox."

[26] Huntsman. *Contr. Can. Biol.*, 1921, No. III, 51-72 (1922).

[27] Piers (*Proc. Trans. N. S. Inst. Sci.*, **16**, 92-95, 1927) reported the occurrence of another species of Whitefish (*Coregonus clupeaformis*) in the Petite Rivière at Millipsigate Lake, Lunenburg County, which was probably artificially introduced into our waters also.

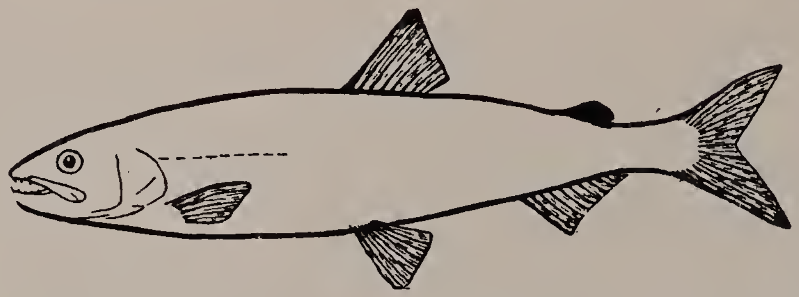
XIX. SMELT FAMILY, *OSMERIDAE.*

Key for genera.

IF: Strong teeth in mouth particularly on tongue; large scales, less than 80 along lateral line; 12 or less rays in pectoral fin:—a Smelt (*Osmerus*), Fig. XXXV.

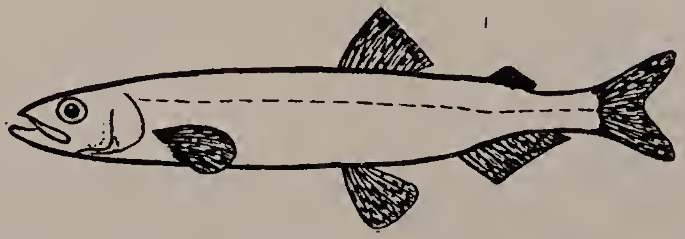
BUT IF: No large teeth; minute scales, about 200 along lateral line; 15 to 20 rays in pectoral fin:—a Capelin (*Mallotus*), Fig. XXXVI.

***Smelt,**
Osmerus mordax
(Mitchill) 1815
(Fig. XXXV).



Very common throughout the coastal waters of the whole region. Of considerable economic importance (annual catch 797,000 pounds, valued at $115,000). Caught principally in fresh water. Scarcely ever reaches more than 10 inches in length[28]. In some Nova Scotian lakes, a landlocked form of Smelt occurs, which is usually larger (up to 14 inches) than the salt water fish.

Capelin,
Mallotus villosus
(Müller) 1777
(Fig. XXXVI).



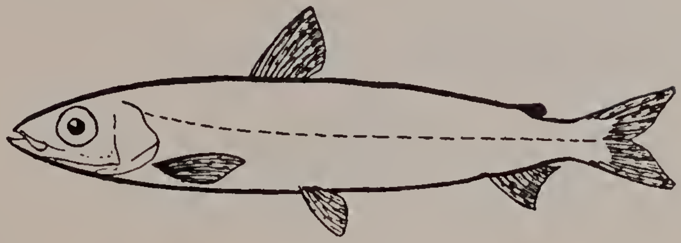
This northern fish is rare, only occasionally visiting our waters. Scarcely ever reaches 8 inches in length. The males have two ridges of scales along each side, one just above the lateral line and another along the side of the belly. At spawning time, these ridges become very pronounced. Usually two males crowd a female between them, holding her by means of these ridges, and all three rush swiftly up the sandy beach to deposit the spawn[29].

[28] Kendall. *U. S. Bull. Bur. Fish.*, **42**, 270-375, (1927).

[29] Sleggs. *Rept. Nfld. Fish. Res. Comm.*, **1**, No. 3, 65 pp., (1933).

XX. ARGENTINE FAMILY, *ARGENTINIDAE.*

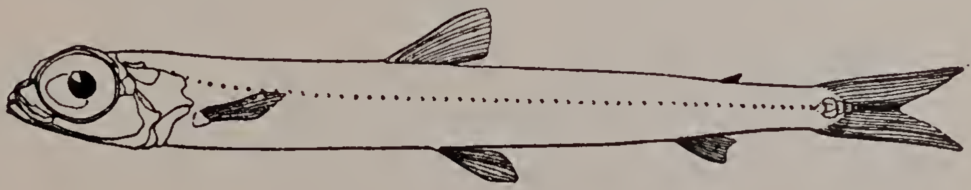
Argentine,
Argentina silus
Ascanius 1763
(Fig. XXXVII).



This rather deep water fish very rare, only one positive record of a capture in our region, and that is of a specimen taken on Sable Island Bank in 200 fathoms (Goode and Bean[5], p. 51). Length about 18 inches.

XXI. LARGE-EYED ARGENTINE FAMILY, *MICROSTOMIDAE.*

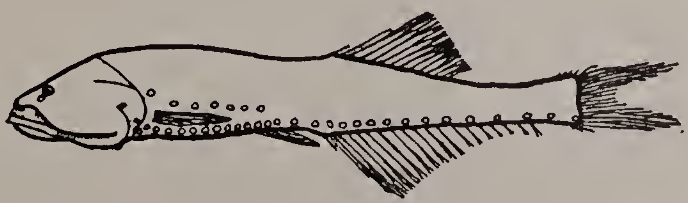
Large-eyed Argentine,
Nansenia gröenlandica
(Reinhardt) 1841
(Fig. XXXVIII).



No doubt this deep water species may be found in our waters (though no records exist). One specimen was recently obtained from the stomach of a Black Swallower (*Chiasmodon niger*) which was captured somewhat south of the boundary of our region (Vladykov[15]). This specimen measuring 9½ inches is the largest ever recorded.

XXII. SMALL-EYED LANTERNFISH FAMILY, *GONOSTOMIDAE.*

Small-eyed Lanternfish,
Cyclothone signata
Garman 1899
(Fig. XXXIX).



Although this deep water fish is probably common outside of the Continental Slope[30], it is very rare in our waters. Positive records of its capture within our region have been made only by Bigelow and Welsh[3] (p. 154) who stated that one specimen was taken in 30 fathoms on Brown's Bank, 1915, and another from the Fundy Deep (90 fathoms), 1920. Of small size, about 2 inches.

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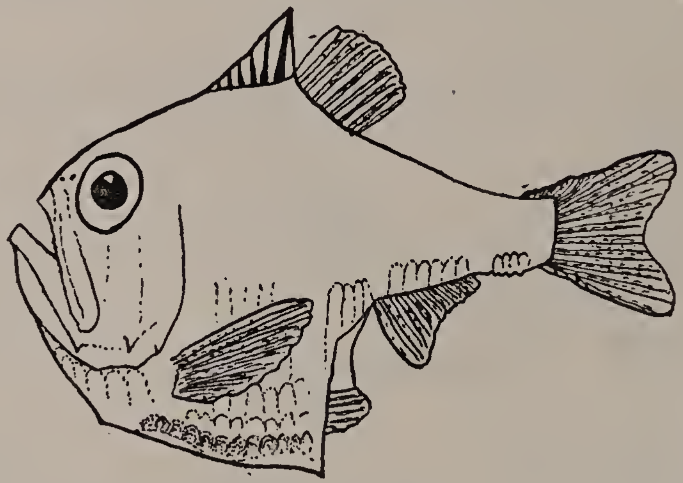
[30] Roule and Angel, (*Res. Comp. Sci. Monaco,* Fasc. 79, 26-38, (1930)), mentioned the capture of several specimens just southeast of the Nova Scotian area.

XXIII. HATCHETFISH FAMILY, *STERNOPTICHIDAE.*

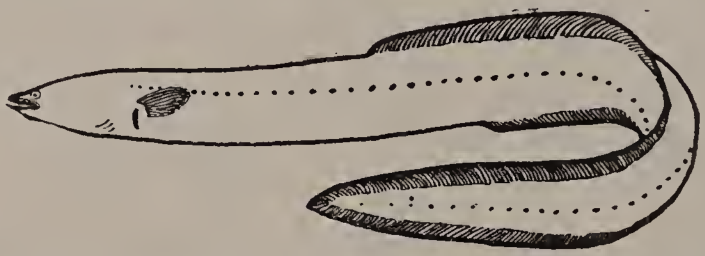
Silver Hatchetfish,
Argyropelecus olfersi
(Cuvier) 1829
(Fig. XL).



A very rare deep water fish, only a single record of its capture within our region is known, and that is of a specimen taken just south of Brown's Bank in 144 fathoms (Goode and Bean[5], p. 127). Length about 2 inches.

XXIV. TRUE EEL FAMILY, *ANGUILLIDAE.*

***Common Eel,**
Anguilla rostrata
(Le Suer) 1817
(Fig. XLI).



Very common in the coastal waters over the whole region. Principal catches, with Eel traps, are made during the summer months (July-August). This fishery amounts to about 136,000 pounds per year with a value of $12,900. Hardly ever more than 4 feet in length and 17 pounds in weight. Grow up in fresh water, but go back to the sea for spawning, journeying to east of Florida and the Bahamas and south of Bermuda where they spawn in deep water, afterwards dying[31].

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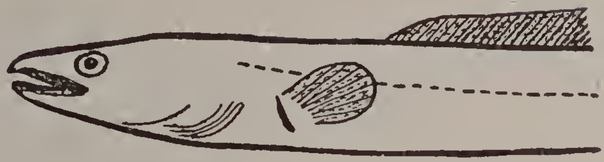
[31] In spite of the general belief, we wish again to emphasize the undoubted fact that *no Eel ever spawns in fresh water.* This astonishing discovery was made by the late Danish scientist, Dr. Joh. Schmidt (*Phil. Trans. Roy. Soc. London, Ser. B.*, **211**, 179-208, (1923)).

XXV. CONGER EEL FAMILY, *CONGRIDAE.*

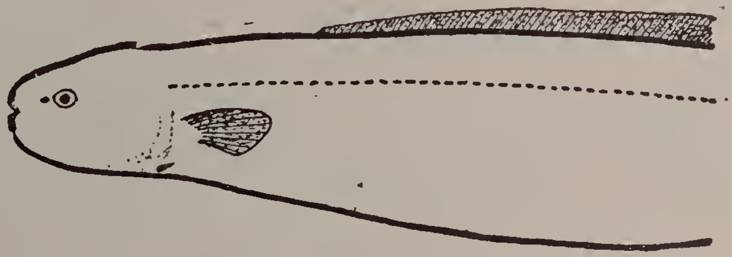
Conger Eel,
Conger conger
(Linnaeus) 1758
(Fig. XLII).



Although no positive record of a capture of this species is known within our region, no doubt the larval stages, at least, will be discovered in our waters, since they are known from closely adjacent waters. This more southern species is much larger than the Common Eel, reaching 8 feet in length.

XXVI. SNUB-NOSED EEL FAMILY, *SIMENCHELYIDAE.*

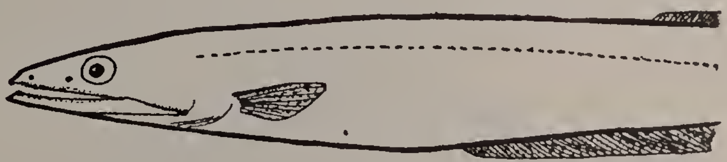
Snub-nosed Eel,
Simenchelys parasiticus
Gill 1879
(Fig. XLIII).



This deep water species rather rare, being reported by Goode and Bean[5] (p. 140) only from Quereau Bank and off Sable Island Bank in 200 to 375 fathoms. Up to about 2 feet in length. It burrows into the muscle of living Halibut and other large fish, after the manner of the Hagfish, and excavates large cavities in the thicker parts of their bodies.

XXVII. LONG-NOSED EEL FAMILY, *SYNAPHOBRANCHIDAE.*

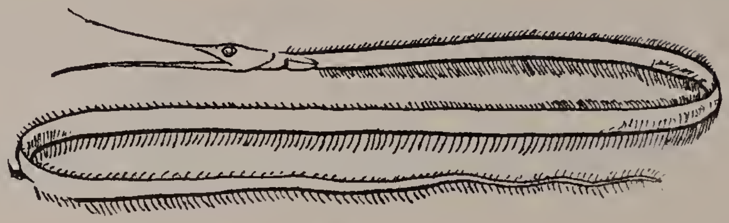
Long-nosed Eel,
Synaphobranchus
pinnatus
(Gronow) 1854
(Fig. XLIV).



This deep water fish not uncommon on the Nova Scotian banks (Quereau, Western and Le Have), being reported from a number of places in depths of 150 to 280 fathoms. Up to about 2 feet in length.

XXVIII. THREAD EEL FAMILY, *NEMICHTHYIDAE.*

Thread Eel,
Nemichthys scolopaceus
Richardson 1848
(Fig. XLV).



This queer deep water form, found in from 300 to 2,000 fathoms, rare in our region. Jones[19] stated that this species was caught on the fishing banks off Nova Scotia. Recently, Roule and Angel[32] (p. 69) listed the capture of a number of specimens along the Continental Slope south of Sable Island Bank. Maximum length about 3 feet.

XXIX. LANTERNFISH FAMILY, *MYCTOPHIDAE.*

The preparation of a comprehensive key for the Lanternfishes is a difficult task, because the different genera and species are distinguished only by very fine characters. For a more complete account of this family, the reader is referred to the very elaborate papers on these fishes by Parr[33]. The above papers have been used extensively in the preparation of the following key.

Key for genera.

Section 1.

IF: Luminous organ on head in front of eye not conspicuously developed; luminous scales developed either on upper or lower surface of tail between adipose and caudal fins; only 2 luminous organs on lower part of base of caudal fin (shown in black in figures):—a Common Lanternfish (*Myctophum*), Fig. XLVII.

BUT IF: Luminous organ on head in front of eye conspicuously developed or not; luminous scales on upper surface of tail present or completely wanting; at least 3 luminous organs on lower part of base of caudal fin:—see Section 2.

Section 2.

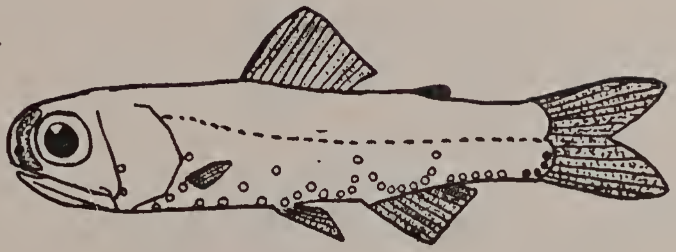
IF: Luminous organ on head in front of eye not conspicuously developed; luminous scales only on upper surface of tail in front of caudal fin; adipose fin wanting:—a Pearly Lanternfish (*Lampanyctes*).

BUT IF: Luminous organ on head in front of eye conspicuously developed; luminous scales on tail wanting; adipose fin present:—a Shiny Lanternfish (*Diaphus*), Fig. XLVI.

[32] Roule and Angel. *Res. Comp. Sci. Monaco,* Fasc. **86,** 120 pp. (1933).

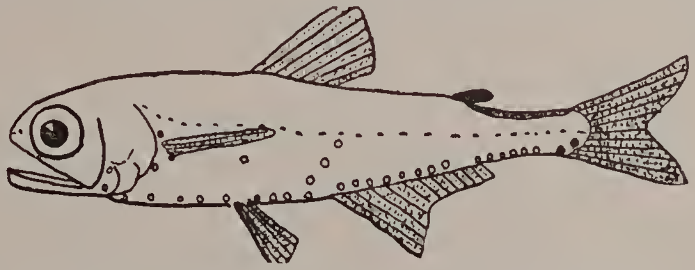
[33] Parr. *Bull. Bingham Ocean. Coll.,* **3,** Art. 3, 193 pp. (1928); and *Proc. U. S. Nat. Mus.,* **76,** Art. 10, 47 pp. (1929).

Shiny Lanternfish,
Diaphus effulgens
(Goode and Bean)
1895
(Fig. XLVI).



This pelagic form (sometimes descends to a depth of 1,639 fathoms) rather rare. For the first time in our waters its capture was reported by Goode and Bean[5] (p. 88), when a specimen was taken from a Cod caught on Brown's Bank. Another specimen was also obtained from a Cod stomach on Western Bank in 1930 (Vladykov[15]). Length about 3 inches. This species, as all other Lanternfishes, lives far away from the shores, ordinarily at considerable depths, coming to the surface at night or in stormy weather, and descending by day.

Common Lanternfish,
Myctophum punctatum
Rafinesque 1810
(Fig. XLVII).



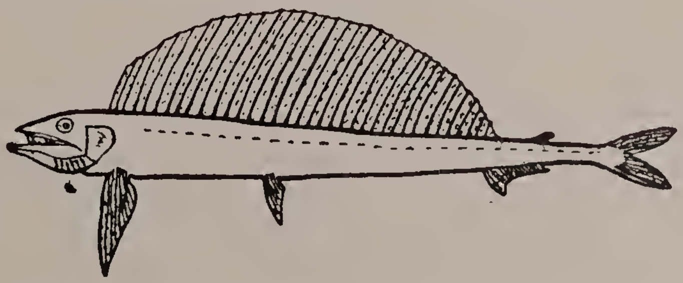
This pelagic form (occurring from the surface down to a depth of about 600 fathoms) is one of the most typical fishes of the High Seas. In our region it has been taken off Quereau Bank (Goode and Bean[5], p. 72). Length up to about 4 inches.

Pearly Lanternfish, *Lampanyctes margaritifer* (Goode and Bean) 1895.

The distribution, habits and size of this fish are the same as for the previous species. It also has been taken on Quereau Bank.

XXX. LANCETFISH FAMILY, *ALEPISAURIDAE.*

Lancetfish,
Alepisauris ferox
Lowe 1833
(Fig. XLVIII).

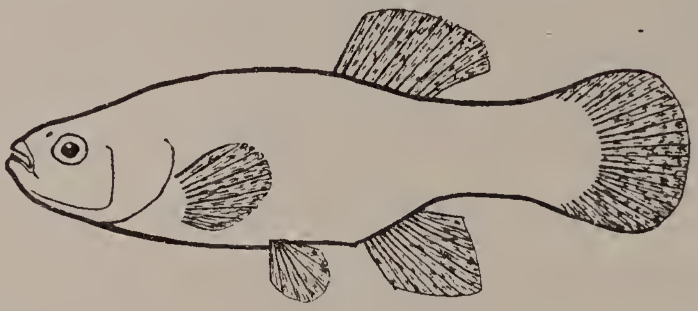


This deep water species rather rare, being taken on Le Have Bank and south of Emerald Bank (Goode and Bean[5],

p. 117). According to Bigelow and Welsh[3] (p. 155) a specimen "taken off Nova Scotia" in August, 1910, was about 6 feet long. More recently, Dr. A. W. H. Needler (personal communication) examined a specimen about 4 feet long (129 cm.) taken about September 1, 1926, in 150 fathoms at the seaward end of "The Gulley" between Sable Island and Quereau Banks. Nothing definitely known of the habits of this species.

XXXI. MUMMICHOG FAMILY, *CYPRINODONTIDAE.*

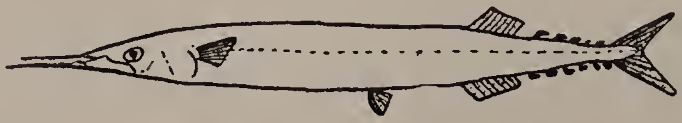
***Mummichog,**
Fundulus heteroclitus
(Linnaeus) 1766
(Fig. XLIX).



Very common throughout the coastal waters (never deeper than 2 fathoms) of the whole region. They are an important article of food for several economic species,—Sea Trout, Eels, etc. This species, as well as another fresh water species (*F. diaphanus*), is commonly known as "Minnows" and both are extensively used as bait for Trout by anglers. Hardly ever reaches 6 inches in length.

XXXII. BILLFISH FAMILY, *SCOMBERESOCIDAE.*

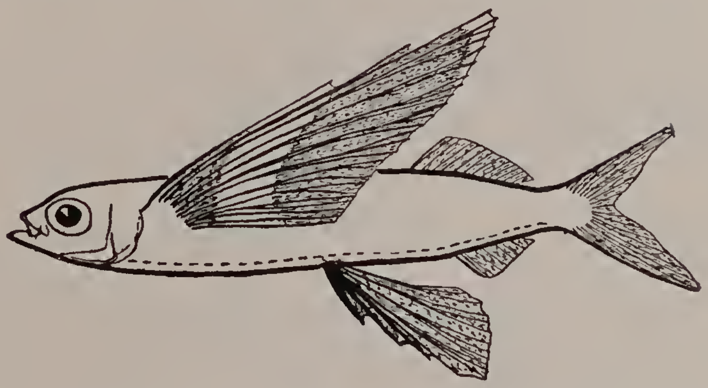
Billfish,
Scomberesox saurus
(Walbaum) 1792
(Fig. L).



Very common summer visitor along the outer coast of Nova Scotia. Usually schooling in large numbers, "skipping" over the surface as they flee from enemies. An important food of Swordfish, Pollock and Tuna. Up to 18 inches in length.

XXXIII. FLYINGFISH FAMILY, *EXOCOETIDAE*.

Flyingfish, *Exocoetes* sp?— (Fig. LI).



Jones[19] states that a specimen of this genus was taken at Sable Island in 1859, but the species was not determined. Probably it was *E. volitans L.* or, according to modern taxonomy, *Exonautes affinis* (Günther), shown in Fig. LI. However, it is possible, also, that it was *Cypselurus heterurus* (Nichols and Breder[34], pp. 59-63). About 12 inches in length. Interesting observations on the flight of these fishes have been made by Hubbs[35].

XXXIV. RAT-TAIL FAMILY, *MACROURIDAE*.

Unfortunately the only specimens in our collection are those of *Macrourus bairdii*. Due to this fact, and as there is no recent revision of this whole group of fishes, it has been impossible to give a really comprehensive key for this family.

Key for genera.

Section 1.

IF: Mouth small, inferior, its cleft not extending to sides of head; teeth all alike on both jaws and very minute:—a Rat-tail (*Macrourus*), Fig. LII.

BUT IF: Mouth wide, its cleft extending to sides of head; among small teeth some large teeth in outer series on upper jaw:—see Section 2.

Section 2.

IF: Teeth in outer series of upper jaw much larger than those in inner series; barbel long, longer than diameter of eye:—a Strap-tailed Grenadier (*Chalinura*).

BUT IF: Teeth in outer series of upper jaw only slightly larger than those in inner series; barbel short, smaller than diameter of eye:—a Rock Grenadier (*Coryphaenoides*).

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[34] Nichols and Breder. *"The Marine Fishes of New York and Southern New England."* New York. 1927, 192 pp.

[35] Hubbs. *Papers Mich. Acad. Sci., Art., Lett.*, **17**, 575-611 (1933).

Rock Grenadier, *Coryphaenoides rupestris* Gunner 1765.

This deep water fish rare, only one positive record of a capture within our region, and that was a single specimen taken many years ago off Quereau Bank (Goode and Bean[5], p. 403). Length up to about 3 feet.

Strap-tailed Grenadier, *Chalinura occidentalis* (Goode and Bean) 1885.

Rare, the only specimen taken in our region was caught in 133 fathoms on Quereau Bank (Goode and Bean[5], p. 414). Up to 10 inches long.

Key of species of genus *Macrourus*.

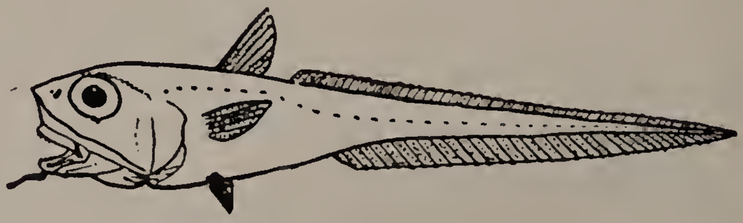
IF: Dorsal spine strongly saw-toothed; first dorsal fin high, about equal to length of head and triangular in shape:—a Common Rat-tail (*M. bairdii*).

BUT IF: Dorsal spine so finely saw-toothed as to appear smooth; first dorsal fin lower, about one-half head length and roundish in shape:—Smooth-spined Rat-tail (*M. berglax*), Fig. LII.

Common Rat-tail, *Macrourus bairdii* (Goode and Bean) 1895.

This deep water form not uncommon on Nova Scotian banks. The most recent finding was that made by the steam trawler *Lemberg*, (Capt. C. Samuelsson), on April 27, 1935, in 26 fathoms on Western Bank. It was about 1 foot long. Numerous records of its capture in neighbouring waters were given by Goode and Bean[5] (pp. 394-396). This species, as other Rat-tails, is a deep sea fish (found in depths from 100 down to 700 fathoms) living on the bottom, and is a weak swimmer. During the cold months, it may be found in shallower waters.

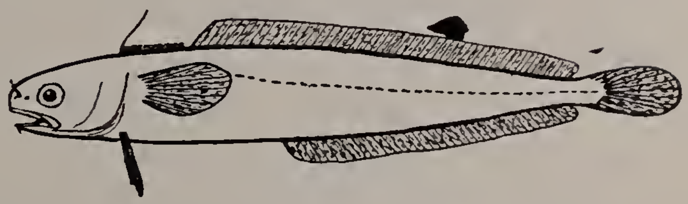
Smooth-spined Rat-tail, *M. berglax* Lacépède (Fig. LII).



This large Rat-tail, up to 3 feet in length and 5 pounds in weight, has been caught on Quereau and Sable Island Banks (Bean[14], p. 80). In general, its habits and distribution are the same as the preceding species.

XXXV. ROCKLING FAMILY, *GAIDROPSARIDAE.*

Common Rockling,
Enchelyopus cimbricus
(Linnaeus) 1766
(Fig. LIII).



Rather common throughout the whole area in coastal and bank waters. Without economic importance. Up to about 1 foot in length.

XXXVI. CODFISH FAMILY, *GADIDAE.*

Key for genera.

Section 1.

IF: 1 long dorsal and 1 long anal fin extending to caudal fin; caudal fin rounded:—a Cusk (*Brosmius*), Fig. LXI.

BUT IF: 2 or 3 dorsal fins; 1 or 2 anal fins; caudal fin rounded or slightly forked:—see Section 2.

Section 2.

IF: 2 dorsal fins, second very long; 1 anal fin, which may be deeply notched even to appearing as 2 separate fins; caudal fin rounded:—see Section 3.

BUT IF: 3 dorsal fins; 2 anal fins; caudal fin slightly forked or rounded:—see Section 4.

Section 3.

IF: Anal fin deeply notched even to appearing as 2 separate fins; snout, flattened above, keeled at sides:—a Blue Hake (*Antimora*), Fig. LVII.

BUT IF: Anal fin not notched; snout rounded above and on sides, not keeled:—a Hake (*Urophycis*), Fig. LX.

Section 4.

IF: Lower jaw projecting beyond upper; chin barbel hardly visible; caudal fin deeply forked; fish uniformly greenish without pattern; lateral line whitish:—a Pollock (*Pollachius*), Fig. LIV.

BUT IF: Lower jaw equal to or shorter than upper; chin barbel well developed; caudal fin rounded or slightly forked; colour not uniformly greenish; lateral line white or black:—see Section 5.

Section 5.

IF: Snout projecting beyond lower jaw; eye large, diameter not less than one-fourth of head length; caudal fin forked; fish silvery-grey with 1 large black patch above pectoral fin; lateral line black:—a Haddock (*Melanogrammus*), Fig. X.

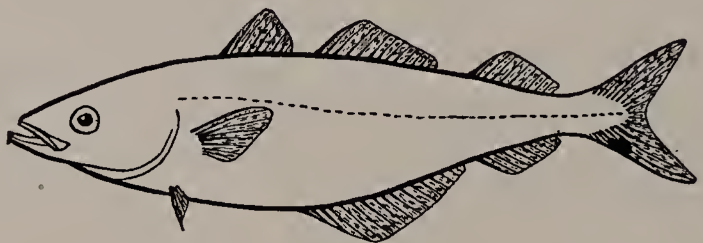
BUT IF: Snout not projecting beyond lower jaw pronouncedly; eye smaller, diameter not more than one-fourth head length; caudal fin rounded or slightly forked; fish without black patch; with whitish lateral line:—see Section 6.

Section 6.

IF: Eye small, diameter not more than one-sixth of head length; chin barbel short; snout projecting beyond lower jaw; all vertical fins, especially the caudal, rounded; maximum size about 15 inches:—a Tomcod (*Microgadus*), Fig. LV.

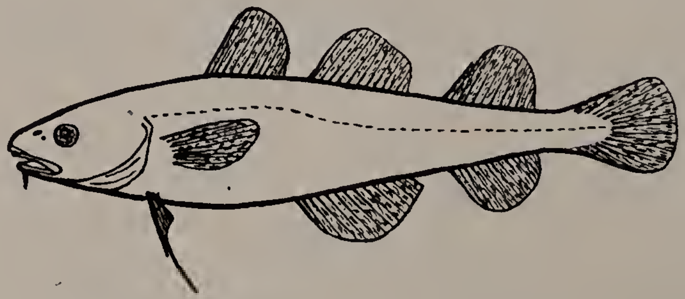
BUT IF: Eye large, diameter not less than one-fifth head length (in specimens of size corresponding to Tomcod, and even larger); chin barbel long; snout not projecting; both jaws about equal; all vertical fins squarish; caudal fin broom-shaped or slightly forked; average size about 25 inches:—a Codfish (*Gadus*), Fig. LVI.

Pollock,
Pollachius virens
(Linnaeus) 1758
(Fig. LIV).



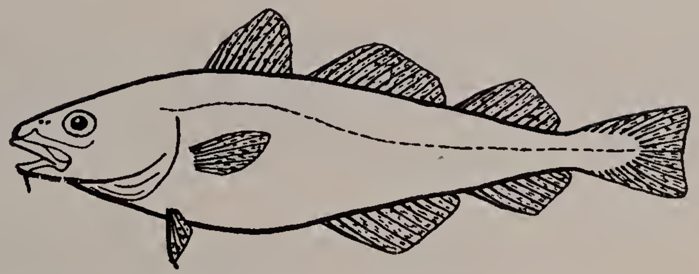
Very common throughout the whole region, particularly abundant off Digby Neck and on certain banks. One of the important commercial and sport species, about 4,187,000 pounds are caught yearly, valued at $62,000. Up to 3½ feet in length and 40 pounds in weight.

***Tomcod,**
Microgadus tomcod
(Walbaum) 1792
(Fig. LV).



Very common in the coastal waters of the whole region. Particularly abundant near and in estuaries. It is of small economic importance, only 28,000 pounds being caught yearly with a value of $400. Maximum length about 14 inches. In many places it is called "Frostfish," because it is caught chiefly during the winter months.

Cod,
Gadus callarias
Linnaeus 1758
(Fig. LVI).

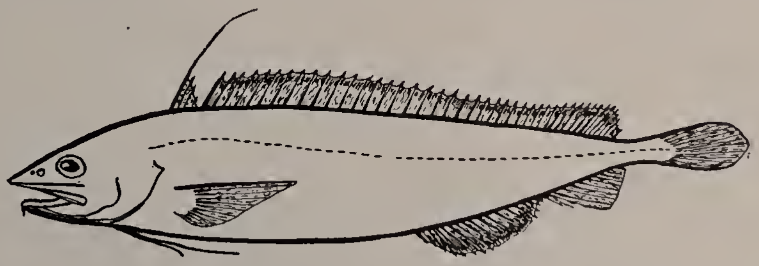


Very common throughout the whole region, and one of the most important commercial fishes, some 60,000,000 pounds are caught annually with a value of $1,500,000[36]. Probably the largest Cod was taken off the Massachussetts coast in 1895, weighing 211¼ pounds and over 6 feet in length[37]. Ambrose[38] reported the capture of another huge Cod taken in 1865 off St. Margaret Bay, which measured 5 feet 10 inches in length. At present, fish over 70 pounds are rather the exception.

Haddock, *Melanogrammus aeglefinus,* (Linnaeus) 1758 (Fig. X).

Very common throughout the whole region, with the main fishery concentrated on the "banks." One of the most important commercial species in our waters, with a yearly catch of about 38,730,000 pounds, having a value of $1,370,000. In our region it hardly ever reaches more than 3 feet in length and 20 pounds in weight, while in northern European waters much larger fish are taken. Thompson[39] reported a recent capture of a Haddock about 44 inches (112 cm.) long in Icelandic waters.

Blue Hake,
Antimora viola
(Goode and Bean)
1878
(Fig. LVII).



Although this deep water fish, according to Bigelow and Welsh[3] (p. 444), is rather plentiful along the Continental

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[36] The amounts shown here are only one-half of those listed in the official statistics for Nova Scotia, because it is estimated that about fifty per cent. of the Cod catches are made outside of our region (e. g., Newfoundland banks).

[37] Jordan and Evermann. "*American food and game fishes.*" New York, **1902,** p. 514.

[38] Ambrose. *Proc. Trans. N. S. Inst. Nat. Sci.,* **1,** Pt. 4, p. 37, footnote (1867).

[39] Thompson. *Fish., Scotland, Sci. Invest.,* 1928, **5,** p. 65 (1929).

Slope in depths of from 350 to 1,000 fathoms, only occasionally is it reported from Nova Scotian banks (Quereau, Sable and Le Have). Length about 2 feet.

Key for species of genus *Urophycis.*

Section 1.

IF: First dorsal fin having no elongated rays; ventral fin scarcely reaching front of anal fin:—a Spotted Hake (*U. regius*), Fig. LVIII.

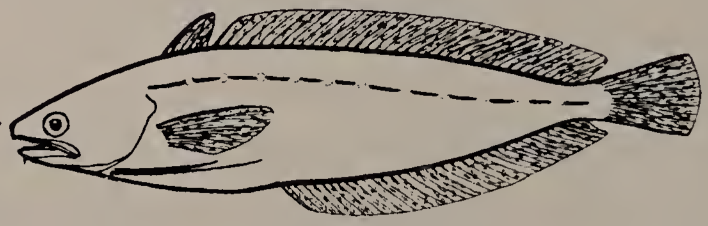
BUT IF: Third ray of first dorsal fin filamentous and greatly elongated reaching to about middle of second dorsal fin; ventral fin extending beyond front of anal fin:—see Section 2.

Section 2.

IF: Ventral fin not reaching middle of anal fin:—a Common Hake (*U. chuss*), Fig. LX.

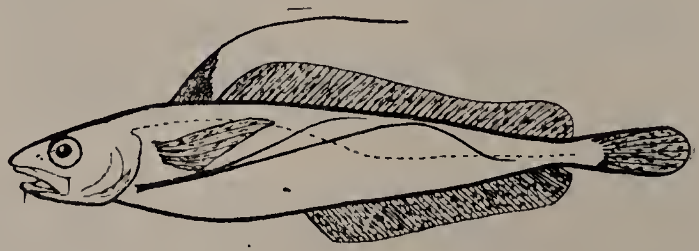
BUT IF: Ventral fin almost reaching posterior end of anal fin:—a Longfinned Hake (*U. chesteri*), Fig. LIX.

Spotted Hake,
U. regius
(Walbaum) 1792
(Fig. LVIII).



This rather southern form very rare. Almost a hundred years ago, Richardson[40] (p. 253) mentioned a specimen "which was captured off Halifax" (no definite locality given). No additional records are known for our waters. Maximum length 16 inches.

Longfinned Hake,
U. chesteri
(Goode and Bean)
1878
(Fig. LIX).



There is only one definite record of the capture of this deep water Hake in our region, and that was of a specimen taken off Halifax (Lat. 44° 26′ N; Long. 62° 10′ W.) in 127 fathoms (Goode and Bean[5], p. 361). However, this species was reported to be abundant along the Continental Slope in depths of from 100 to 500 fathoms (Bigelow and Welsh[3], p. 456). It is the smallest of our Hakes, reaching only about 11 inches in length.

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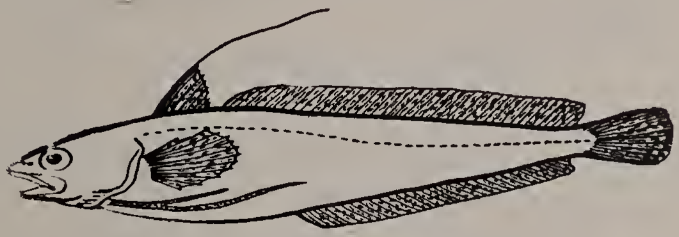
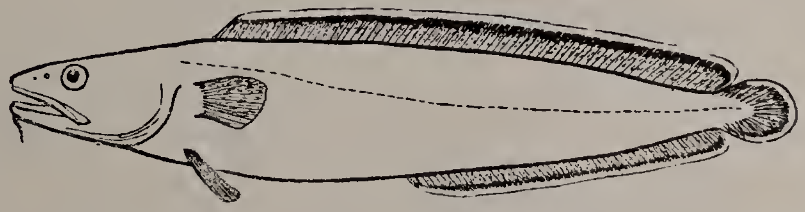
[40] Richardson. *Fauna Boreali-Americana,* **3**, 253 (1836).

Common Hake,
U. chuss
(Walbaum) 1792[41]
(Fig. LX).



Very common throughout the whole area, being a very important commercial species. The yearly yield of this Hake fishery is about 11,000,000 pounds, in value $170,000[42], The maximum length is about 3 feet (37 inches, our own record). and weight 17 pounds. However, much larger individuals are caught on the Atlantic banks, since Mr. W. H. Boutilier, Vice-President in charge of operations, Maritime National Fish Co., Limited, assures us that specimens weighing up to 60 pounds are frequently taken. The young Hake are sometimes found hiding in living Scallop shells.

Cusk,
Brosme brosme
(Müller) 1776
(Fig. LXI).



This commercial fish common throughout the whole region in rather deep water over a hard bottom. The Cusk fishery amounts yearly to about 1,000,000 pounds and $18,000 in value. Maximum length about 3 feet and weight 30 pounds.

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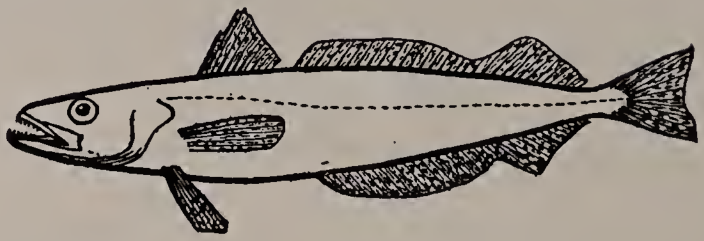
[41] We consider *U. tenuis* (Mitchill) 1815 as synonymous with *U. chuss* from a study of literature. However, a comparison of Hake obtained from the Bay of Fundy (Digby) with those from the Atlantic Banks shows certain dissimilarities, whose taxonomic significance must be determined by a more intensive study.

[42] In the official statistics, the Hake and Cusk catches are recorded as one. However, it may be stated that the Hake fishery amounts roughly to at least 90 per cent. of the total. The amounts shown above were determined on this basis.

XXXVII. SILVER HAKE FAMILY, *MERLUCIIDAE.*

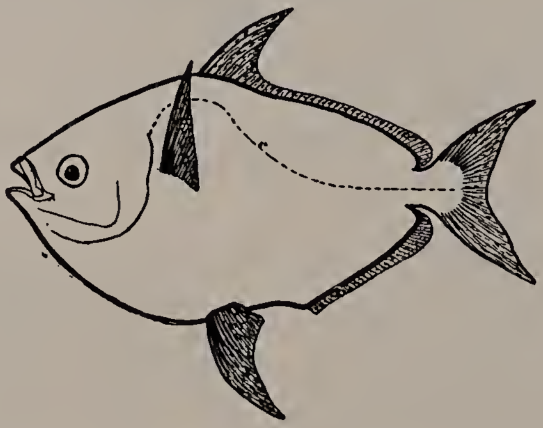
Silver Hake,
Merluccius bilineatus
(Mitchill) 1814
(Fig. LXII).



Very common over the whole region, particularly abundant during the warmer months. Without economic importance at present, being, however, a good edible and sport fish. Adult Silver Hake prey on Herring and Mackerel, and very often damage these fishes in nets. But young Silver Hake, in turn, constitute an important part of the diet of Cod, Pollock, etc. Maximum length about 2 feet and weight 8 pounds[48].

XXXVIII. OPAH FAMILY, *LAMPRIDAE.*

Opah,
Lampris regius
(Bonnaterre) 1788
(Fig. LXIII).



This pelagic fish rather rare. Only the following records of its capture in our waters are known: Jones[19] stated that a specimen was taken at Sable Island during the late fifties (1856?), and Goode and Bean[5] (p. 223) recorded the capture of another specimen off Le Have Bank, while the most recent capture was made on Brown's Bank in the spring of 1932, when a specimen 4½ feet in length was taken (Vladvkov[15]), Length up to 6 feet.

[48] The closely related, or even identical, European form (*M. merluccius*), attains a much larger size. According to Belloc ("Etude monographique du Merlu (*Merluccius merluccius L.*)" Par. 2. *Rev. Trav. Office Pêch. Marit. II*, p. 237, **1929**) it reaches a length of 4⅓ feet and a weight of 32 pounds.

XXXIX-XLI. FLATFISHES, *HETEROSOMATA*.

In spite of the fact that our Flatfishes belong to three different families[44], they are popularly considered as one group. In view of this it is considered advisable to make a single key for all the genera of Flatfishes, regardless of family differences. This key is based mainly on examination of material, as well as information from the literature, of which the comprehensive data on eastern Canadian species published by Huntsman[7] were of particular help.

Flatfishes may be easily distinguished from any other of our fishes by the fact that both eyes are situated on one (pigmented) side of the head, while the other, blind side, usually remains unpigmented (Fig. XI). Attention is called to the fact that Skates also have both eyes on the pigmented surface, which, however, is the back, not the side, of the fish. (For details, see description of the Skate family, X). However, it may be mentioned that all young Flatfishes shorter than about half an inch have a symmetrical body and an eye on each side of the head. As they grow older, the eye on one side gradually shifts close to the other, and the fish then develops the habit of lying on one side, blind side towards the bottom. Generally, the fish of one species have the eyes on the same side of the head.

When the fish is placed in front of the observer, pigmented side up and the guts next to the observer, then, if both eyes are on the observer's right, the fish is right-handed, but if both eyes are on the observer's left, the fish is left-handed. The majority of our Flatfishes are right-handed (Fig. XI), only two of them (the Summer Flounder, Fig. LXV, and Sand Flounder, Fig. LXIV) are left-handed. Occasionally, among individuals of a right-handed species, one may find a left-handed fish, but such exceptions are quite rare. In such an instance the other systematic characters mentioned in the key make the proper identification of the specimen possible. The most important characters are shown in black in the corresponding figures.

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[44] In this paper, the systematic arrangement of Flatfishes by Jordan, Evermann and Clark (*Rept. U. S. Comm. Fish.* 1928, Pt. II, 217-228, **1930**) has been adopted because it is more generally recognized on this continent. Norman, "*A Systematic Monograph of the Flatfishes*", I. London. **1934**, 439 pp, in his new revision of this group has used another family arrangement.

Key for genera.

Section 1.

IF: Fish right-handed; mouth small; posterior end of maxillary scarcely reaching front of eye; caudal fin rounded:—see Section 2.

BUT IF: Fish either right or left-handed; mouth large; maxillary reaching posterior edge of eye; caudal fin either rounded, forked or of another shape:—see Section 5.

Section 2.

IF: Lateral line pronounced arched over pectoral fin; body thin; several, irregular, rusty, red spots on coloured side; yellow tinge on tail and around base of long fins on blind side (unpigmented side):—a Yellowtail (*Limanda*), Fig. LXXI.

BUT IF: Lateral line almost straight, or only slightly arched; no rusty spots on pigmented side nor yellow tinge to blind side:—see Section 3.

Section 3.

IF: Blind side of dark hue; pectoral fin on pigmented side black; body shape elliptical in outline; about 100 rays in dorsal and anal fins respectively:—a Witch (*Glyptocephalus*), Fig. LXVIII.

BUT IF: Blind side almost white; pectoral fin brownish not black; body shape roundish; only about 50 rays in dorsal and anal fins respectively:—see Section 4.

Section 4.

IF: Head between eyes scaleless; bony ridge present; pigmented surface rather smooth, lateral line very distinct and straight; fish almost round and rather thin:—a Smooth Flounder (*Liopsetta*), Fig. LXIX.

BUT IF: Head between eyes covered with scales, bony ridge absent; pigmented surface rough to touch; lateral line not so distinct and slightly arched over pectoral fin; fish not so round and rather thick bodied:—a Winter Flounder (*Pseudopleuronectes*), Fig. LXX.

Section 5.

IF: Fish left-handed; ventral fins not symmetrical, that on pigmented side extending from tip of isthmus to beginning of anal fin (giving impression that these 2 fins are continuous); upper part of some of anterior dorsal rays free from membrane; lateral line well arched over pectoral fin;

caudal fin rounded; pigmented side with dark spots on body and fins; body thin:—a Sand Flounder (*Lophopsetta*), Fig. LXIV.

BUT IF: Fish either left or right-handed; ventral fins symmetrical, even that on pigmented side being well separated from tip of isthmus and anal fin; no free rays in dorsal fin; lateral line either straight or arched; caudal fin rounded, forked or of another shape:—see Section 6.

Section 6.

IF: Fish right-handed; lateral line almost straight:—see Section 7.

BUT IF: Fish either right or left-handed; lateral line well arched:—see Section 8.

Section 7.

IF: Caudal fin round; teeth rather weak; blind side whitish:—a Canadian Plaice (*Hippoglossoides*), Fig. LXVII.

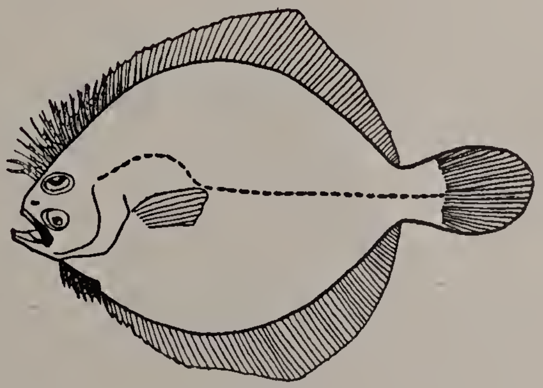
BUT IF: Caudal fin slightly forked; teeth strong; blind side greyish not whitish:—a Greenland Halibut (*Reinhardtius*), Fig. LXVI.

Section 8.

IF: Fish right-handed, of large size; middle rays of caudal fin shorter than lateral, and this fin forked; dorsal beginning over eye, not in front of it; the blind side white in smaller fish and greyish in larger:—a Halibut (*Hippoglossus*), Fig. XI.

BUT IF: Fish left-handed and of smaller size; middle rays of caudal fin longer than lateral, hence this fin rounded or cross-bow shaped; dorsal beginning in front of eye; blind side whitish:—a Summer Flounder (*Paralichthys*), Fig. LXV.

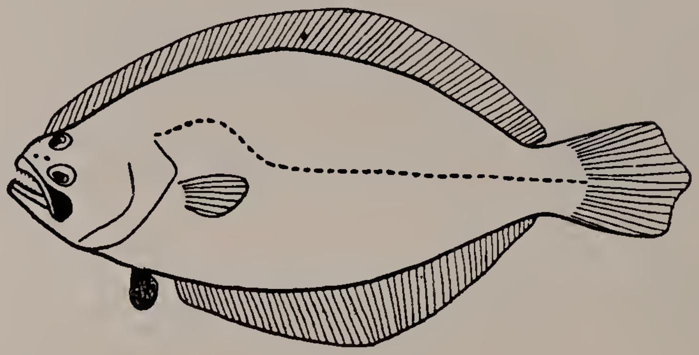
Sand Flounder,
Lophopsetta maculata
(Mitchill) 1814
(Fig. LXIV).



This rather southern form distributed sporadically in our region, being found mainly in Minas Basin, St. Mary Bay and on certain parts of Western Bank. Of little economic importance. Maximum length 18 inches and weight about 2 pounds.

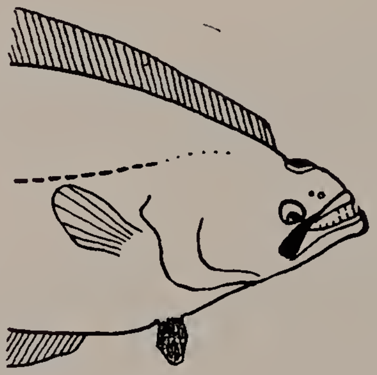
XL. HALIBUT FAMILY, *HIPPOGLOSSIDAE.*

Summer Flounder,
Paralichthys dentatus
(Linneaus) 1766
(Fig. LXV).



There is only one positive record of the capture of this southern fish in our region, and that was of a specimen taken on Le Have Bank (Lat. 43° 3′ N; Long. 63° 39′ W.) in 85 fathoms during the *Challenger* Expedition (Günther[45], p. 3). Reaches a maximum length of 3 feet and weight of 26 pounds.

Greenland Halibut,
Reinhardtius
hippoglossoides
(Walbaum) 1792
(Fig. LXVI).



This northern form rather uncommon, being reported a number of times as caught on the Nova Scotian banks only. It has been more often taken off Canso on a muddy bottom in about 50 fathoms (Cornish[46], p. 90). Of slight economic importance due to its scarcity in our region. Attains a maximum length of about 3 feet and weight of 25 pounds.

Halibut, *Hippoglossus hippoglossus* (Linnaeus) 1758 (Fig. XI).

Common throughout whole region, being caught chiefly in the deeper water and on the "banks." Economically the most important Flatfish, about 2,600,000 pounds being caught yearly with a value of $387,000. The largest of our Flatfishes, reaching a maximum length of about 10 feet and 700 pounds in weight. Our own records show that every year odd fish, weighing 500 to 600 pounds, are caught in the Bay of Fundy.

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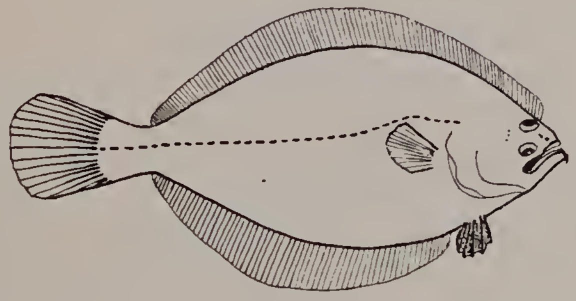
[45] Günther. *Challenger Rept.* Shore Fishes, Zoology, **1**, p. 3 (1880).

[46] Cornish. *Contr. Can. Biol.*, **1902-05**, 81-90 (1907).

Canadian Plaice,
Hippoglossoides platessoides
(Fabricius) 1780
(Fig. LXVII).



Probably our most abundant and commonest Flatfish, being usually found in from 10 to 50 fathoms over a sandy bottom. This species composes the major part (Halibut excepted) of the bank Flatfish catches. The total yearly catch of all Flatfishes (excluding Halibut) amounts to about 1,400,000 pounds and $63,000 in value. The largest North American specimen on record is that of 28¼ inches in length, caught by the steam trawler *Viernoe* (Capt. F. Tidman) on Western Bank, September 6, 1934.

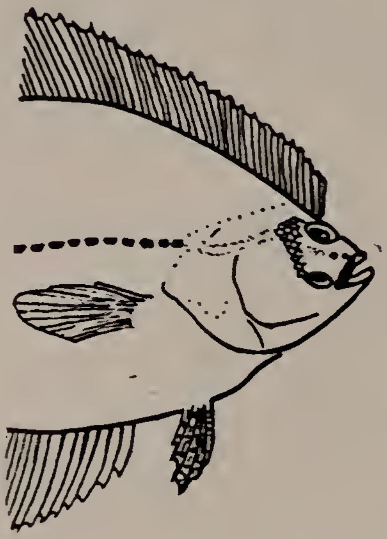
XLI. FLOUNDER FAMILY, *PLEURONECTIDAE.*

Witch,
Glyptocephalus cynoglossus
(Linnaeus) 1758
(Fig. LXVIII).

Very common throughout the whole region in rather deep water, sometimes as deep as 858 fathoms (Goode and Bean[5],

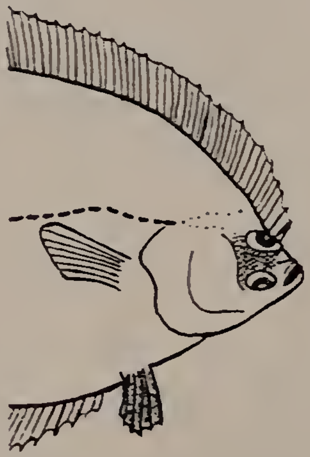
p. 433). Of slight economic importance because of its rather watery flesh. Maximum length about 2 feet and weight of 5 pounds.

Smooth Flounder,
Liopsetta putnami
(Gill) 1864
(Fig. LXIX).



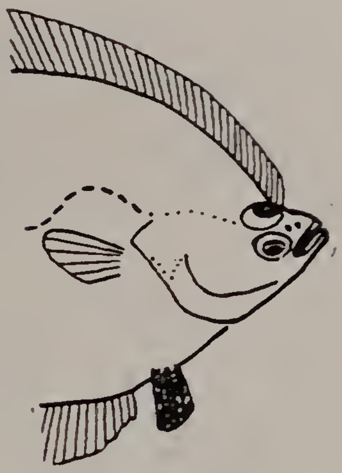
This northern form rather uncommon, being found in shallow waters over a muddy bottom. Without economic importance. It is the smallest of our Flatfishes, the maximum length being about 1 foot and 1½ pounds in weight.

Winter Flounder,
Pseudopleuronectes americanus
(Walbaum) 1792
(Fig. LXX).



Very common in shallow waters (usually less than 20 fathoms) throughout the whole region. A variety of this species found on the Nova Scotian banks, and sometimes called "Lemon Sole," plays an important part in the Flatfish fishery. The Lemon Sole reaches a larger size than the inshore fish. The largest specimen from North American waters was that caught by the steam trawler *Viernoe* (Capt. F. Tidman) on September 8, 1934, on Western Bank. It was 25 inches in length and 8 pounds in weight.

Yellowtail,
Limanda ferruginea
(Storer) 1839
(Fig. LXXI).



Very common over the whole area, particularly abundant on the "banks" in depths from 20 to 30 fathoms. Important economic species, with a more delicious flavour than any other of our Flatfishes. Length up to 2 feet.

XLII. STICKLEBACK FAMILY, GASTEROSTEIDAE.

Key for genera.

Section 1.

IF: 8 to 11 free spines in front of dorsal fin; a keel along each side of posterior part of body and tail; a bony plate between and behind ventral fins:—a Nine-spined Stickleback (*Pungitius*), Fig. LXXIII.

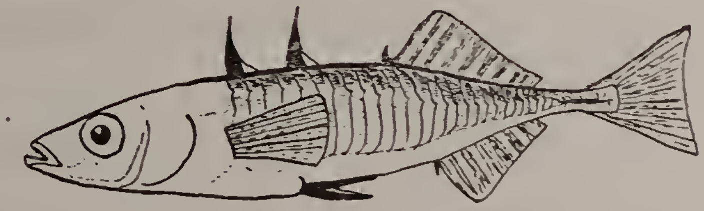
BUT IF: Less than 6 free spines in front of dorsal fin; keel and bony plate between ventral fins either present or absent:—see Section 2.

Section 2.

IF: Body usually possessing bony plates (varying in number from 0 to 33), 2 long, stout spines on back in addition to 1 small spine immediately in front of dorsal fin; a keel along each side of posterior part of body; a bony plate between and behind ventral fins:—a Three-spined Stickleback (*Gasterosteus*), Fig. LXXII.

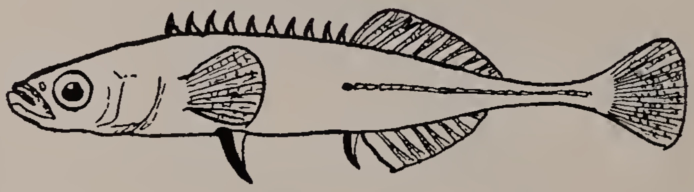
BUT IF: Body naked, without bony plates; as a rule 3 stout, free spines in addition to 1 smaller spine immediately in front of dorsal fin; keels absent, 2 narrow, bony plates 1 on each side of belly, not between ventral fins:—a Four-spined Stickleback (*Apeltes*), Fig. LXXIV.

***Three-spined Stickleback,**
Gasterosteus aculeatus
Linnaeus 1758
(Fig. LXXII).



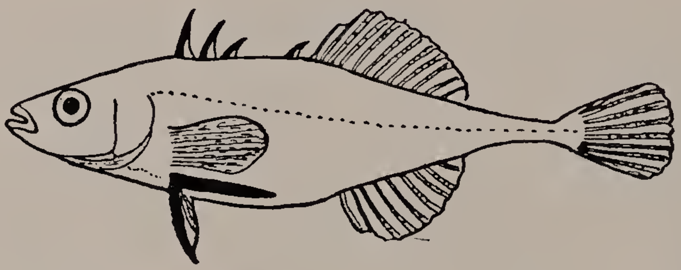
Extremely abundant in very shallow water along the whole shoreline of the region, as well as in estuaries and creeks. Without economic importance. Maximum length about 4 inches. The males of this species, as well as other Stickleback species, build nests of aquatic plants. The eggs are deposited in the nests by the females and protected thereafter by the males only.

***Nine-spined Stickleback,**
Pungitius pungitius
(Linnaeus) 1758
(Fig. LXXIII).



This fish is similar to the Three-spined species in abundance, distribution and habits. However, it occurs more often in fresh water than the above species, and does not grow quite as large.

***Four-spined Stickleback,**
Apeltes quadracus
(Mitchill) 1815
(Fig. LXXIV).



Rather common along the coast of the whole region, being, however, almost exclusively a salt and brackish water species. Without economic importance and less than 3 inches in length.

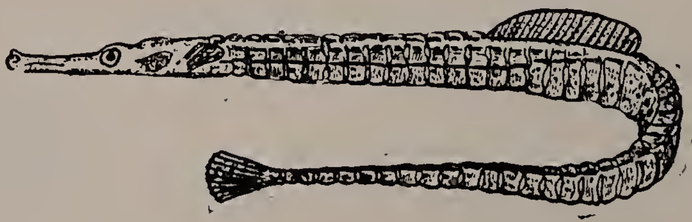
XLIII. SEA HORSE FAMILY, *SYNGNATHIDAE.*

Key for genera.

IF: Body elongated, needle-like; head long with tube-like snout; caudal fin present:—a Pipefish (*Syngnathus*), Fig. LXXV.

BUT IF: Body rather short, divided into stout front part and long tail curled inwards; head horse-like; caudal fin absent:—a Sea Horse (*Hippocampus*), Fig. LXXVI.

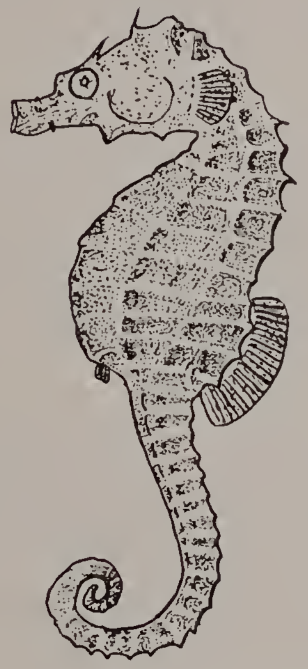
Pipefish,
Syngnathus fuscus
(Storer) 1839
(Fig. LXXV).



Rather common in the coastal waters of the whole region in warm water amongst Eel grass and other aquatic vegetation. Without economic importance. Up to 12 inches in length.

Since the days of Aristotle it has been known that the Pipefish incubates its eggs in a brood pouch. This pouch is found on the ventral surface of the male only, who takes care of the eggs until they hatch.

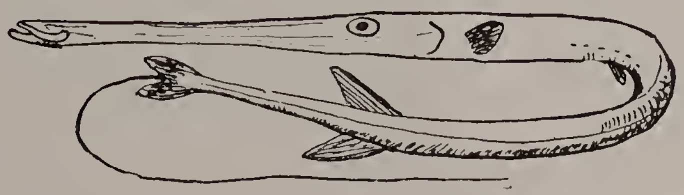
Sea Horse,
Hippocampus hudsonius
DeKay 1842
(Fig. LXXVI).



There are only odd records of the occurrence of this southern fish in our region. These are from the shore waters of the Atlantic coast of Nova Scotia. Less than 8 inches in length. The male protects the eggs in the same manner as described for the Pipefish. No doubt other species of Sea Horse may stray into our region from the south (Vladykov[15]).

XLIV. TRUMPETFISH FAMILY, *FISTULARIIDAE.*

Trumpetfish,
Fistularia serrata
Cuvier 1817[47]
(Fig. LXXVII).



This southern form very rare. Odd captures from time to time have been reported from the Atlantic coast of Nova

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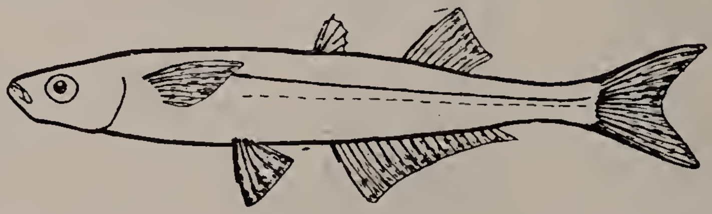
[47] Jones (see footnote 19) listed another species, *F. tabacaria L.*, from our area, besides *F. serrata*. However, the specimens of the Provincial Museum examined by us are similar to the description and illustration of *F. serrata* given by Günther., (*loc. cit.*, p.p. 68-69, pl. xxxii. It may be mentioned also that distinction between different species of *Fistularia* is quite difficult (Meek and Hildebrand, *Field Mus. Nat. Hist. Pub. No.* 250, *Zool. Ser.*, **15**, 249-254, 1923). Thus, in our list we consider Jones' *F. tabacaria* as synonymous with *F. serrata*.

Scotia as far northeast as Halifax Harbour. Several specimens are exhibited in the Provincial Museum at Halifax. The more recent record is of a capture of a specimen off Port Mouton, N. S., 1931 (Vladykov[15]). This species reaches a length of about 5 feet.

XLV. SILVERSIDE FAMILY, *ATHERINIDAE.*

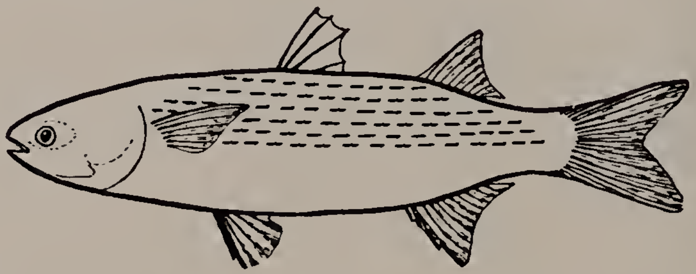
Silverside,
Menidia notata
(Mitchill) 1815
(Fig. LXXVIII).



This species is found rather sporadically in shallow, inshore waters, as well as in brackish waters. It prefers shallow, sandy inlets where the water becomes quite warm in summer. Up to about 6 inches in length.

XLVI. MULLET FAMILY, *MUGILIDAE.*

Mullet,
Mugil cephalus
Linnaeus 1758
(Fig. LXXIX).



There is only one record of a capture of this southern species in our region, and that is of a young specimen taken in Bedford Basin, Halifax Harbour, 1931 (Vladykov[15]). In southern waters it reaches a length of about 2 feet.

XLVII. MACKEREL FAMILY, *SCOMBRIDAE.*

Key for genera.

Section 1.

IF: 2 dorsal fins far apart, separated by a space equal to at least one-half of head length; 2 keels present on each side at base of caudal fin:—see Section 2.

BUT IF: 2 dorsal fins close together, almost touching; 3 keels present on each side at base of caudal fin:—see Section 3.

Section 2.

IF: Eye small; air bladder absent; first dorsal fin with 10 to 14 spines; sides below lateral line silvery, not spotted:—a Mackerel (*Scomber*), Fig. LXXX.

BUT IF: Eye large; air bladder present; first dorsal fin with 9 or 10 spines; sides below lateral line mottled with dusky blotches:—a Chub Mackerel (*Pneumatophorus*), Fig. LXXXI.

Section 3.

IF: Pectoral and ventral fins about equal in length; first dorsal fin slightly higher than second; teeth on vomer absent; sides having black longitudinal bands:—a Bonito (*Sarda*), Fig. LXXXII.

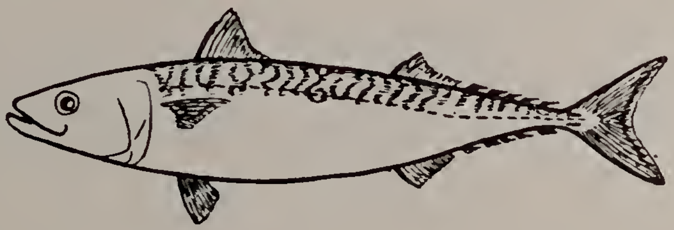
BUT IF: Pectoral fin much longer than ventral fin; first dorsal fin lower than second; minute teeth on vomer; sides without black longitudinal bands:—see Section 4.

Section 4.

IF: Pectoral fin short, about one-half length of head; fish large, usually longer than 6 feet and over 200 pounds in weight:—a Tuna (*Thunnus*), Fig. VIII.

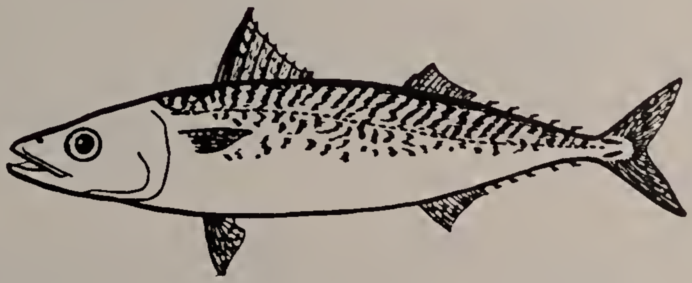
BUT IF: Pectoral fin long, about one and a half times length of head; fish smaller, less than 4 feet in length and 70 pounds in weight:—a Long-finned Tuna (*Germo*), Fig. LXXXIII.

Mackerel,
Scomber scombrus
Linnaeus 1758
(Fig. LXXX).



Very common throughout the whole region, particularly abundant in the numerous bays along the shore during the summer months. Mackerel is well known as a marine sport fish, and it is also one of the most important commercial species with a yearly catch of about 11,350,000 pounds, having a value of $379,000. Length up to 20 inches, and weight to about 4 pounds.

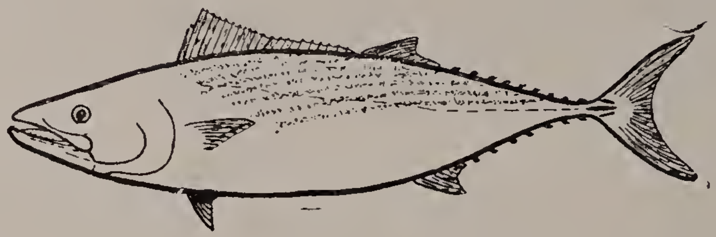
Chub Mackerel,
Pneumatophorus colias
(Gmelin) 1788
(Fig. LXXXI).



This species rather uncommon in our region. Probably a small number are mixed every year with the Mackerel.

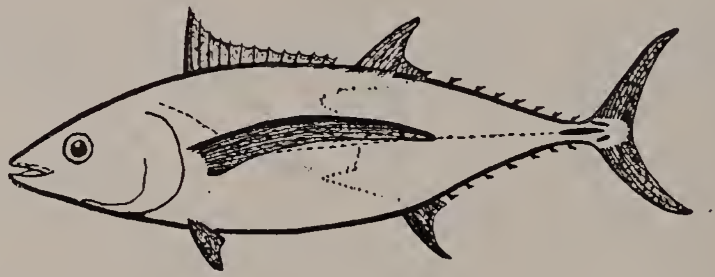
However, it is only recently that its definite occurrence has been recorded (Vladykov[15]). Without economic importance. Length about 1 foot.

Bonito,
Sarda sarda
(Bloch) 1793
(Fig. LXXXII).



Only two positive records of the capture of this more southern form in our waters are known (Vladykov[15]). Length up to about 3 feet, and weight to 15 pounds.

Long-finned Tuna,
Germo alalunga
(Gmelin) 1788
(Fig. LXXXIII).



The occurrence of this southern form in our region is similar to that of the Bonito (Vladykov[15]). Much smaller than the Tuna, reaching only about 70 pounds in weight.

Tuna or Albacore *Thunnus thynnus* (Linnaeus) 1758 (Fig. VIII).

Common summer visitor, only along the outer coast of Nova Scotia. One of the highly prized sport fishes, as well as an important commercial species. The annual catch is about 233,000 pounds, with a value of $14,000. This yield could be easily increased, due to the abundance of the fish, if market conditions were more favourable. It is one of the largest of our fishes. The record specimen measuring 10¼ feet in length and weighing 956 pounds was caught off Liverpool, N. S., on August 17, 1934 with rod and line[48]. Specimens less than 60 pounds are only occasionally seen in our region.

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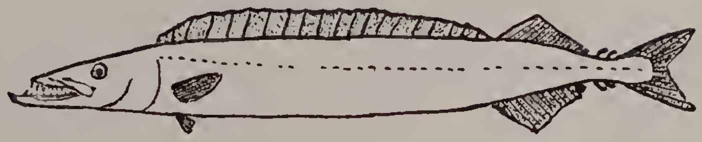
[48] This information is taken from the pamphlet *"Deep Sea Fighters,"* issued by the Highway Department of Nova Scotia, Halifax, **1935**, 16 pp.

XLVIII. OILFISH FAMILY, *GEMPYLIDAE.*

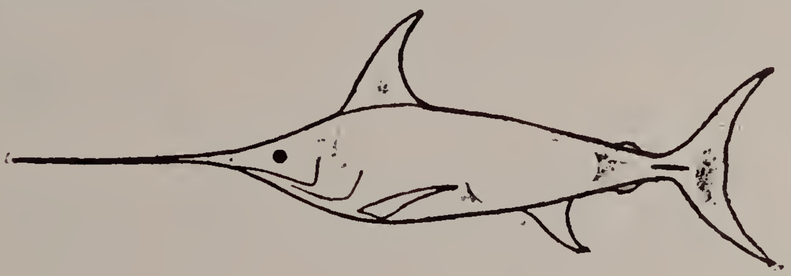
Oilfish,
Escolar violaceus
(Bean) 1887
(Fig. LXXXIV).



There is only one positive record of a capture of this southern deep water species in our waters, and that was of a specimen taken on Le Have Bank in 125 fathoms many years ago (Goode and Bean[5], p. 195). This specimen measured about 4 feet in length.

XLIX. SWORDFISH FAMILY, *XIPHIIDAE.*

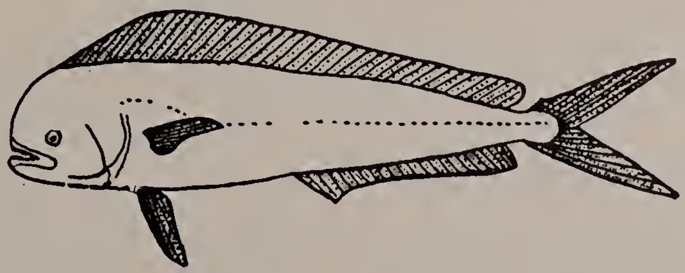
Swordfish,
Xiphius gladius
Linnaeus 1758
(Fig. LXXXV).



A common summer visitor only, along the outer coast of Nova Scotia. Particularly abundant off the east coast of Cape Breton. One of the best sport fishes, as well as an important commercial fish. The annual yield is about 970,000 pounds, with a value of $149,000. Reaches a weight of about 700 pounds, slightly smaller than the Tuna. Younger specimens, less than 50 pounds, are seldom found in our waters.

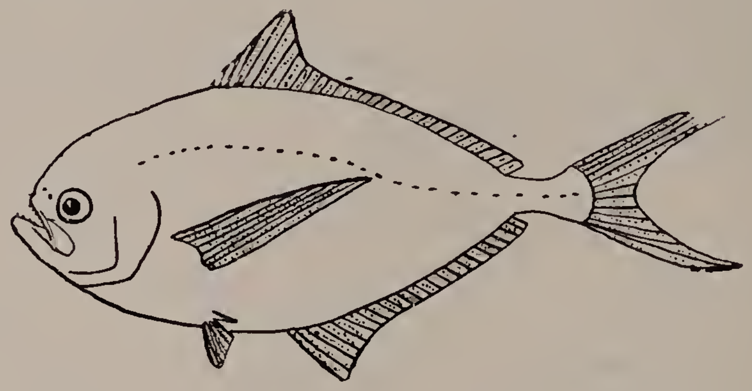
L. DOLPHIN FAMILY, *CORYPHAENIDAE.*

Dolphin,
Coryphaena hippurus
Linnaeus 1758
(Fig. LXXXVI).



This southern pelagic fish extremely rare. Only one specimen, about 2 feet in length, has ever been caught in our waters, and that was taken in Bedford Basin, Halifax Harbour, on August 7, 1901. This is exhibited in the Provincial Museum, Halifax (No. 357). In southern waters it reaches a length of 6 feet. This Dolphin is an extremely fast-swimming fish, feeding to a considerable extent on Flyingfishes.

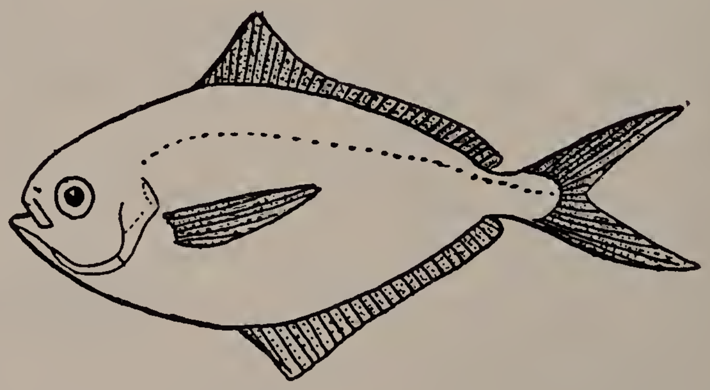
LI. SEA BREAM FAMILY, *BRAMIDAE.*



Sea Bream,
Taractes princeps
Johnson 1863
(Fig. LXXXVII).

This rather southern fish extremely rare. Only one specimen has been caught in our waters, and this was taken on Brown's Bank, January 10, 1928 (Bigelow and Schroeder[4]). Originally this species was described from Madeira, where it reaches a length of about 30 inches.

LII. DOLLARFISH FAMILY, *STROMATEIDAE.*

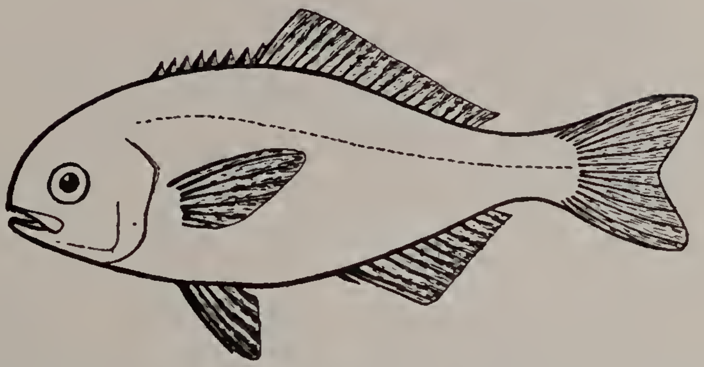


Dollarfish,
Poronotus triacanthus
(Peck) 1800
(Fig. LXXXVIII).

A not uncommon summer visitor in the coastal waters of the whole region. Without economic importance. Hardly ever reaches 1 foot in length. The name is derived from its round shape and silvery colour.

LIII. BARRELFISH FAMILY, *CENTROLOPHIDAE.*.

Barrelfish,
Palinurichthys perciformis
(Mitchill) 1818
(Fig. LXXXIX).



Rather rare, being known only from the outer coast of Nova Scotia, where the capture of the odd specimen probably takes place every year during the summer months. Reaches a length of 1 foot. They owe their common name to the habit of congregating around wreckage or inside of floating boxes and barrels, which serve as shelter. There they may be easily caught with dipnets.

LIV. HARDTAIL FAMILY, *CARANGIDAE.*

Key for genera.

Section 1.

IF: 1 finlet behind each dorsal and anal fin:—a Mackerel Scad (*Decapterus*), Fig. XC.

BUT IF: No finlet behind either dorsal or anal fin:—see Section 2.

Section 2.

IF: Body very thin, depth not less than one-half body length; first dorsal reduced to merely a few spines, the anterior of which may be connected by a membrane, the fin, as a whole, much lower than second dorsal; ventral fin very short, smaller than diameter of eye:—see Section 3.

BUT IF: Body not very thin; depth not more than one-third of body length; first dorsal fin well developed, about equal in height to second dorsal fin; ventral fin longer than diameter of eye:—see Section 4.

Section 3.

IF: Anterior rays of both second dorsal fin and anal fin not pronouncedly elongated, only about equal to posterior rays of respective fins; a row of keeled shields along posterior part of lateral line:—a Common Moonfish (*Vomer*), Fig. XCII.

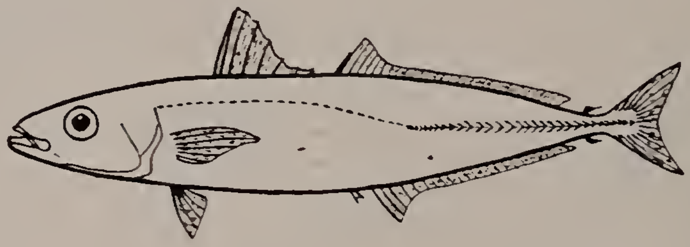
BUT IF: Anterior rays of both second dorsal fin and anal fin pronouncedly elongated, at least eight times as long as posterior rays of respective fins; no keeled shields along posterior part of lateral line:—a Horsehead Moonfish (*Argyreiosus*).

Section 4.

IF: Shoulder girdle having a deep cross furrow near its juncture with isthmus and a fleshy knob above it; eye large, diameter not less than one-third of head length:—a Big-eyed Scad (*Trachurops*).

BUT IF: Shoulder girdle having no furrow, fleshy knob absent; eye small, diameter not more than one-fourth of head length:—a Hardtail (*Caranx*), Fig. XCI.

Mackerel Scad, *Decapterus macarellus* (Cuvier and Valenciennes) 1833 (Fig. XC).



So far as is known, the only two specimens captured in our region were taken in the Chedabucto Bay trap-nets near Canso, N. S. (Cornish[46], p. 85). It reaches about 1 foot in length. The Mackerel Scad, as the other members of this family, is pelagic in habit, being common in more southern waters.

Big-eyed Scad, *Trachurops crumenophthalma* (Bloch) 1793.

This form is equally as rare as the Mackerel Scad. Only the capture of two specimens has been reported from our region, and these were taken in the Canso vicinity (Cornish[46], p. 85). Maximum length 15 inches.

Key for species of genus *Caranx*.

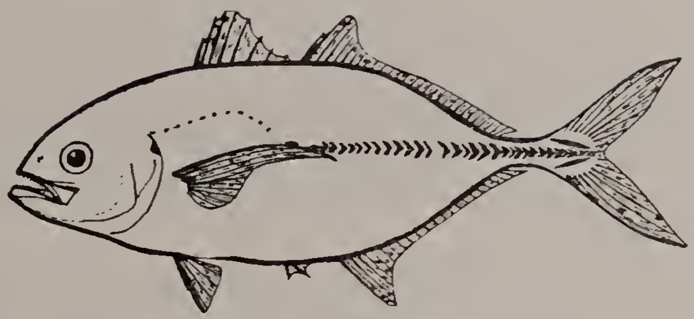
IF: Breast naked except for a small triangular patch of scales immediately in front of ventral fins; number of keeled shields along lateral line 26 to 30:—a Jack (*C. hippos*).

BUT IF: Breast fully scaled, number of keeled shields along lateral line 38 to 45:—a Hardtail (*C. crysos*), Fig. XCI.

Jack, *C. hippos* (Linnaeus) 1766.

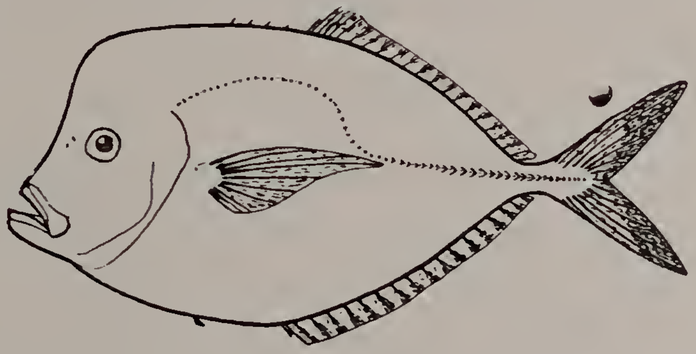
This rare species had not been reported from our region until recently, when three small specimens (about 1½ inches in length) were caught in Musquodoboit Harbour in the summer of 1933 (Vladykov[15]). In southern waters it attains a maximum size of about 20 pounds.

Hardtail,
C. crysos
(Mitchill) 1815
(Fig. XCI).



This species is more commonly found in our region than any of the other members of the Hardtail family. Probably every year a few specimens are found along the outer coast of this province during the late summer months. It reaches a weight of about 3 pounds in southern waters. Specimens straying into our region are hardly ever over 1 foot in length.

Common Moonfish,
Vomer setapinnis
(Mitchill) 1815
(Fig. XCII).



Small specimens (about 2 inches in length) are sometimes found during the warm months along the outer coast of this province (Leim[49]; Vladykov[15]). In southern waters it reaches about 1 foot in length.

Horsehead Moonfish, *Argyreiosus vomer* (Linnaeus) 1758.

Very rare in our region. According to Jones[19] and Honeyman[50] (p. 328) occasional specimens were taken in the inshore waters of this province. In southern regions it grows to a size of about 2 pounds.

LV. PILOTFISH FAMILY, *SERIOLIDAE.*

Key for genera.

IF: First dorsal fin represented by 4 short spines practically without connecting membrane, second dorsal fin with 25 to 27 soft rays; mouth small; posterior edge of maxillary scarcely reaching front of eye; body depth about one-quarter of body length:—a Pilotfish (*Naucrates*).

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[49] Leim. *Proc. N. S. Inst. Sci.*, **17**, Pt. 4, p. xlvi (1930).

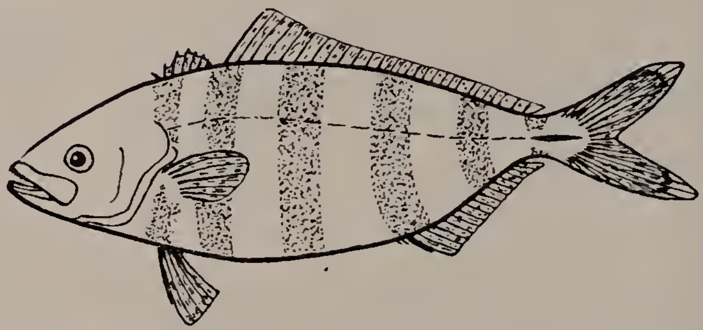
[50] Honeyman. *Trans. N. S. Inst. Nat. Sci.*, **6**, Pt. 4, 228-232; 328-330 (1886).

BUT IF: First dorsal fin well developed, consisting of 6 to 7 spines connected by a membrane; second dorsal with 36 to 40 soft rays; mouth somewhat larger, maxillary practically reaching middle of eye; body depth about one-third of body length:—a Rudderfish (*Seriola*), Fig. XCIII.

Pilotfish, *Naucrates ductor* (Linnaeus) 1758.

Many years ago, Honeyman[50] (p. 330) presumably observed this rare species in our region. During recent years (1932-34) three specimens, caught on Nova Scotian banks, have been at our disposal (Vladykov[15]). These specimens are all around 16 inches in length. In southern waters, this species reaches about 2 feet in length. The name Pilotfish is derived from its habit of following ships and larger sharks. The general belief that it leads sharks to food is probably erroneous.

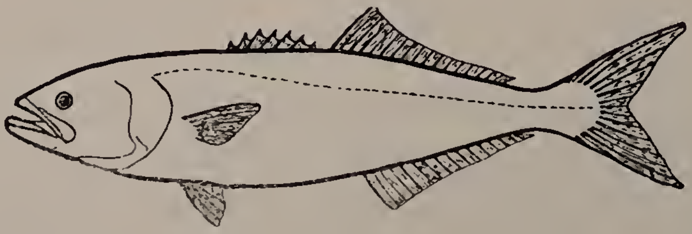
Rudderfish,
Seriola dumerili
(Risso) 1810
(Fig. XCIII).



Young specimens (about 7 inches in length) of this fish are more commonly found than the Pilotfish during summer months along the shores of the outer coast of Nova Scotia. In southern waters this pelagic fish reaches a maximum weight of 100 pounds (Hildebrand and Schroeder[51], p. 218). This species is quite well known to our fishermen, as it is often seen around buoys, floating wreckage, etc.

LVI. BLUEFISH FAMILY, *POMATOMIDAE.*

Bluefish,
Pomatomus saltatrix
(Linnaeus) 1758
(Fig. XCIV).



This pelagic southern form rare, only odd specimens being reported from our waters, and these mainly off Yarmouth

[51] Hildebrand and Schroeder. *Bull. U. S. Bur. Fish.*, 43, 366 pp. (1928).

(personal observations) and Liverpool, N. S. (Leim[49]). In southern waters it reaches about 3 feet in length, and is a highly prized edible fish.

LVII. WHITE BASS FAMILY, *MORONIDAE.*

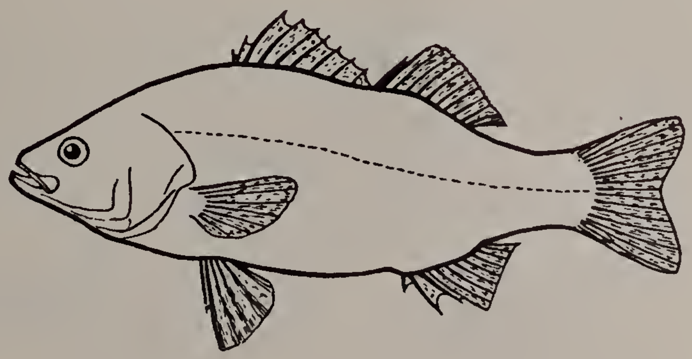
Key for genera.

IF: First dorsal fin separated from second dorsal fin by a space about equal to twice diameter of eye; scales small, about 65 along lateral line; eye small, about one-seventh of head length; longitudinal dark stripes on side:—a Striped Bass (*Roccus*), Fig. IX.

BUT IF: 2 dorsal fins meeting at their bases; scales larger, about 53 along lateral line; eye larger, about one-quarter head length; sides not distinctly striped:—a White Perch (*Morone*), Fig. XCV.

***Striped Bass,** *Roccus saxatilis* (Walbaum) 1792 (Fig. IX).

Rather rare in salt water, being more often found close to and in estuaries, relatively plentiful in the Shubenacadie River and Grand Lake. A highly prized sport and commercial fish, but it is not very abundant in this province. The yearly catch is only about 7,600 pounds, valued at $800. Specimens up to about 50 pounds in weight have been caught in Grand Lake. The largest specimen, weighing about 125 pounds and 6 feet in length, was taken at Edenton, N. C., in 1891 (Bigelow and Welsh[3], p. 252).

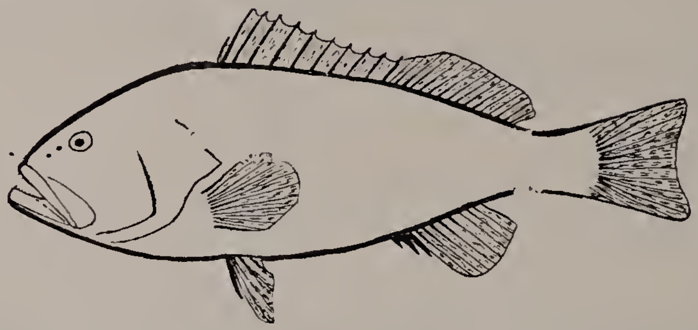


***White Perch,**
Morone americana
(Gmelin) 1789
(Fig. XCV).

It is commonly found in a number of Nova Scotian lakes, while in salt and brackish waters it is not so frequently seen. A very good sport and edible fish. Maximum length about 15 inches and weight 3 pounds.

LVIII. SEA BASS FAMILY, *EPINEPHELIDAE.*

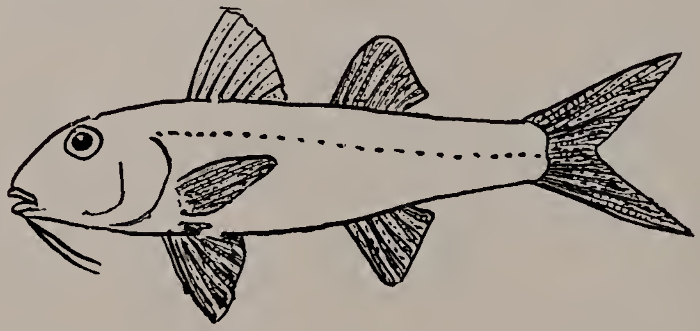
Red Grouper,
Epinephelus morio
(Cuvier and Valenciennes) 1828
(Fig. XCVI).



Only two young specimens (about 1 inch in length) of this rare southern species are known to have been captured in our waters, and these were taken in Eastern Passage, Halifax Harbour, October 12, 1928 (Vladykov[15]). In southern waters it grows to about 3 feet in length.

LIX. SURMULLET FAMILY, *MULLIDAE.*

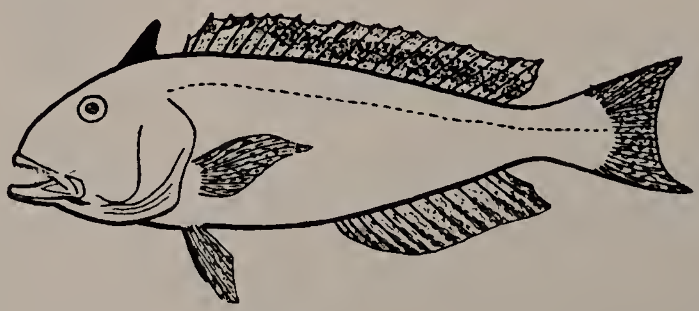
Red Mullet,
Mullus auratus
Jordan and Gilbert
1882
(Fig. XCVII).



Only one specimen (3 inches long) of this southern species has been caught in our region, and this was taken along with the Red Grouper in 1928 (Leim[49]), as mentioned above. Length up to about 8 inches. The Mediterranean species (*M. surmuletus*) was famous in Roman times, when large amounts of money were spent in keeping this fish in glass vessels in order to see the exquisite play of colours in dying specimens.

LX. TILEFISH FAMILY, *BRANCHIOSTEGIDAE.*

Tilefish,
Lopholatilus chamaeleonticeps
Goode and Bean
1879
(Fig. XCVIII).

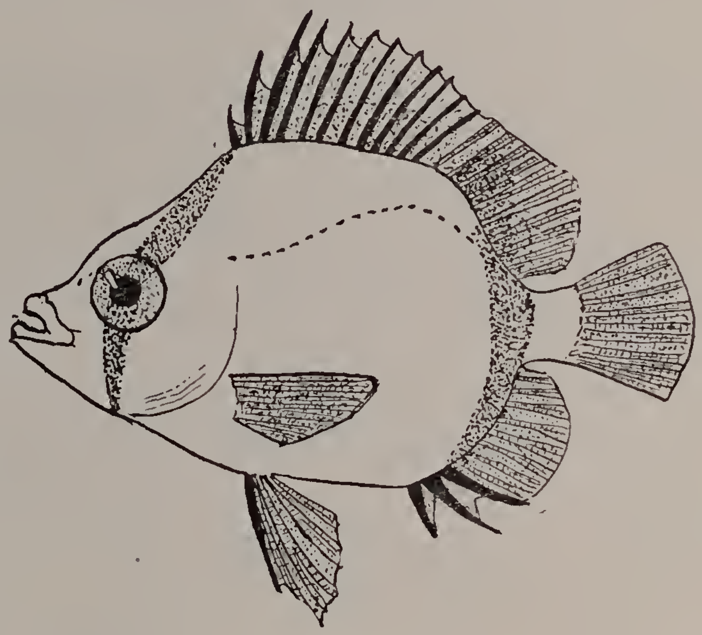


The only positive record of a capture of this rare fish in our region was that of a small specimen taken on Quereau

Bank and reported by Smith[52]. Reaches, in southern waters, about 50 pounds in weight. It is a peculiarity of the Tilefish that extraordinary mortality occurs among them from time to time over large areas.

LXI. BUTTERFLY FISH FAMILY, *CHAETODONTIDAE.*

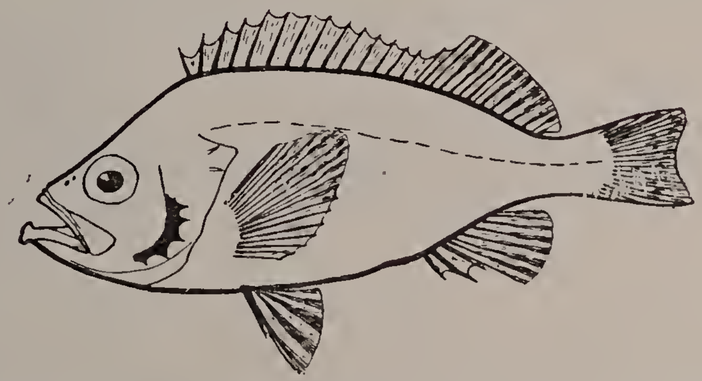
Common Butterfly Fish,
Chaetodon ocellatus
Bloch 1787
(Fig. XCIX).



Only one specimen (about 1 inch in length) of this rare fish has been captured in our waters, and that was taken in Musquodoboit Harbour in 1933 (Vladykov[15]). In southern waters it reaches a length of about 8 inches. It is a typical coral reef species, flitting about from place to place in a rather butterfly-like fashion.

LXII. ROCKFISH FAMILY, *SCORPAENIDAE.*

Rosefish,
Sebastes marinus
(Linnaeus) 1758
(Fig. C).



Common throughout our whole region in water of about 20 to 50 fathoms in depth. Particularly abundant during

[52] Smith. *U. S. Comm. Fish and Fish. Rept. Commiss.* 1903, p. 85 (1905).

winter months on Western Bank where as many as 2,000 pounds per haul may be taken by the steam trawlers. Without economic importance at present, although the flesh is very tasty. It is regrettable that it is not generally used for human consumption in this country. Reaches a maximum length of 2 feet and weight of 12 pounds.

LXIII. SCULPIN FAMILY, *COTTIDAE.*

Key for genera.

Section 1.

IF: Only 1 dorsal fin consisting of a spiny-rayed anterior part and a soft-rayed posterior part:—a Deep-sea Sculpin (*Cottunculus*).

BUT IF: 2 separate dorsal fins, first spiny and second soft-rayed:—see Section 2.

Section 2.

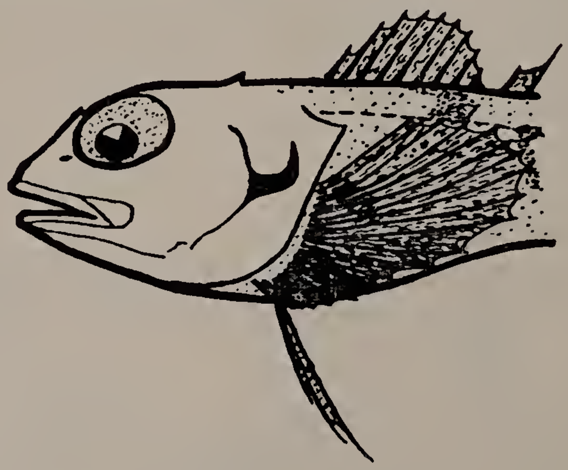
IF: Anal fin long with at least 20 rays; about 45 bony plates on each side of body:—a Mailed Sculpin (*Triglops*), Fig. CII.

BUT IF: Anal fin short, with less than 16 rays; no bony plates along sides of body:—see Section 3.

Section 3.

IF: Eye large, diameter about one-third of head length; upper large spine on edge of cheek strongly curved upwards; head and body naked; fish of smaller size, not more than 4 inches in length:—a Hook-eared Sculpin (*Artediellus*), Fig. CI.

BUT IF: Eye smaller, diameter not more than one-quarter of head length; upper and all other spines on cheek straight, not curved; head and body naked or covered with odd patches of bony shields; fish usually more than 5 inches in length:—a Common Sculpin (*Myoxocephalus*), Fig. CIII.



Hook-eared Sculpin,
Artediellus uncinatus
(Reinhardt) 1833
(Fig. CI).

Not uncommon, being reported from a number of places off the outer coast of Nova Scotia in water of 50 to 190 fathoms in depth (Goode and Bean[5], p. 268). Without economic importance. Growing to about 4 inches in length.

Mailed Sculpin, *Triglops pingeli* Reinhardt 1832 (Fig. CII).

Rather common, being particularly numerous on Western Bank where it constitutes part of the food of Cod. Without economic importance. Up to 8 inches in length.

Deep-sea Sculpin, *Cottunculus microps* Collett 1875.

Rare, being reported only by Goode and Bean[5] (p. 270) from south of Brown's Bank in water of from 122 to 141 fathoms in depth. Length about 8 inches.

Key for species of genus *Myoxocephalus.*

Section 1.

IF: Spines on head sharp; upper spine on margin of cheek very long, about four times longer than the one below it and reaching to posterior margin of gill cover:—a Long-horned Sculpin (*M. octodecimspinosus*), Fig. CIV.

BUT IF: Spines on head rather blunt; upper spine on margin of cheek only twice as long as the one below it, and reaching only half-way to posterior margin of gill cover:—see Section 2.

Section 2.

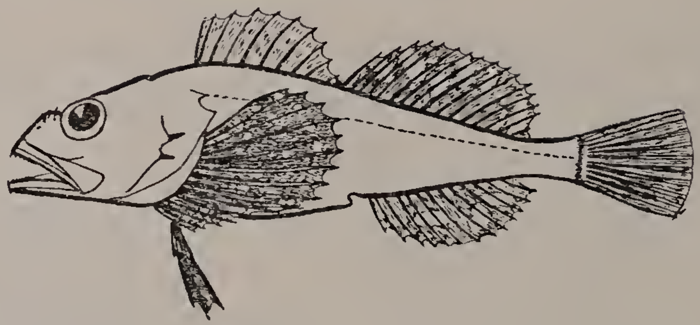
IF: Anal fin having 10 to 11 rays; second dorsal fin 13 to 14 rays; head and body naked; fish never longer than 8 inches:—a Little Sculpin (*M. aeneus*).

BUT IF: Anal fin having 13 to 14 rays; second dorsal fin having 16 to 17 rays; fish usually between 8 and 14 inches in length:—a Common Sculpin (*M. scorpius gröenlandicus*), Fig. CIII.

Little Sculpin, *M. aeneus* (Mitchill) 1815.

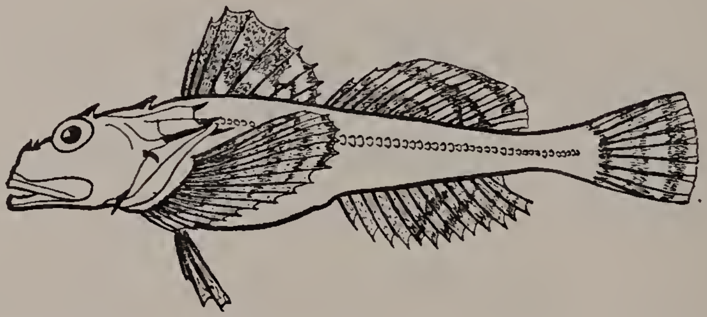
Common in coastal waters along the whole region. Usually found in shallow inlets during the summer. Without economic importance. Maximum length about 8 inches.

Common Sculpin,
M. scorpius gröenlandicus
(Cuvier and Valenciennes) 1829
(Fig. CIII).



Very common throughout the whole region in shallow water from 2 to about 20 fathoms in depth. Is seldom seen on the "banks." Without economic importance. Grows to a length of about 3 feet. The typical form of this species is distributed throughout northern European waters.

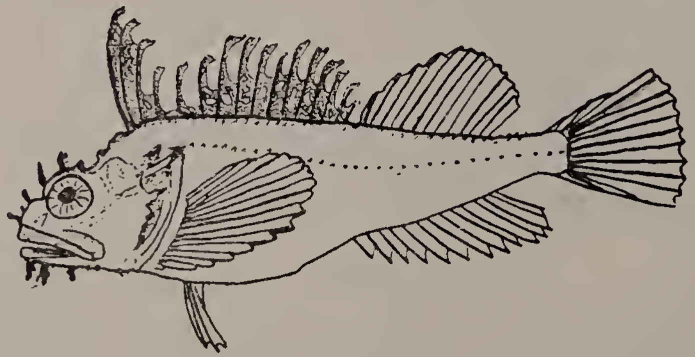
Longhorned Sculpin,
M. octodecimspinosus
(Mitchill) 1815
(Fig. CIV).



Very common throughout the whole region, but in deeper water (10 to 50 fathoms) than the previous species. Also without economic importance, being rather a nuisance to fishermen, as it often becomes entangled in the nets and also greedily takes baited hooks on line trawls. The very long spines on this Sculpin quite often wound the fishermen's hands when removing it from the gear. Length about 1½ feet.

LXIV. SEA RAVEN FAMILY, *HEMITRIPTERIDAE*.

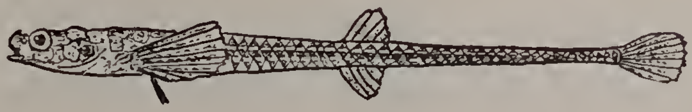
Sea Raven,
Hemitripterus americanus
(Gmelin) 1788
(Fig. CV).



Very common throughout the whole region, usually being found in water from 15 to 50 fathoms in depth. Without economic importance. Maximum length about 25 inches and weight 5 pounds. When taken from the water it usually exerts its power of inflating the belly like a balloon. Because of this, it is frequently called "Puff Belly."

LXV. ALLIGATORFISH FAMILY, *ASPIDOPHOROIDIDAE.*

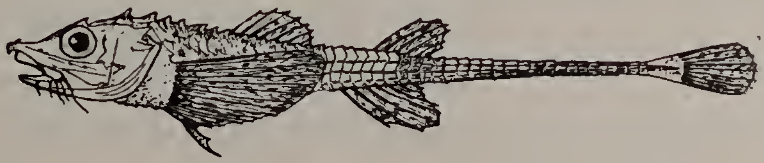
Common Alligatorfish,
Aspidophoroides monopterygius
(Bloch) 1786
(Fig. CVI).



Very common throughout our whole region. Sometimes found as deep as 100 fathoms. Without economic importance. Length up to about 7 inches. The name Alligatorfish is derived from the fact that it is covered with regular bony plates, reminding one of the bony shields of an Alligator.

LXVI. SEA POACHER FAMILY, *AGONIDAE.*

Northern Alligatorfish,
Leptagonus decagonus
(Black and Schneider) 1801
(Fig. CVII).



This northern form very rare. Only recently Thompson[53] (p. 127) reported the capture of a young specimen near the surface on Quereau Bank in 1932. This is the first record of this species in our waters. Reaches a maximum of about 8 inches.

LXVII. LUMPFISH FAMILY, *CYCLOPTERIDAE.*

Key for genera.

IF: 2 dorsal fins, first persisting throughout life; head and body rounded and covered with large, sharply pointed bony tubercles; fish less than 5 inches in length:—a Spiny Lumpfish (*Eumicropterus*).

BUT IF: Only 1 dorsal fin, (in adult first dorsal fin covered with flesh and not noticeable while in the very young both fins may be seen); head and body triangular in shape, covered with smaller, blunt tubercles; fish usually over 6 inches in length:—a Common Lumpfish (*Cyclopterus*), Fig. CVIII.

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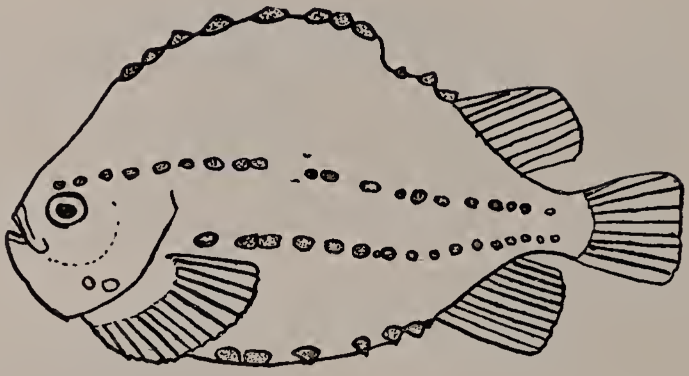
[53] Thompson. *Rept. Nfld. Fish. Res. Comm.,* **2,** No. I, 125-127 (1933).

Common Lumpfish,
Cyclopterus lumpus
Linnaeus 1758
(Fig. CVIII).



Common over the whole region, usually found in shallow waters under floating sea weeds or under wharves. Without economic importance, although it is a good edible fish. Length up to 20 inches and weight about 50 pounds.

Spiny Lumpfish, *Eumicropterus spinosus* (Müller) 1777.

This northern form very rare, being only occasionally reported from our waters (Jones[19]). About 5 inches in length.

LXVIII. SEA SNAIL FAMILY, *LIPARIDAE.*

Key for genera[54].

Section 1.

IF: Anterior 6 rays of dorsal fin separated from posterior part of fin by a deep notch; sucking disc large, diameter about five times that of eye; skin of the head and body rather firm not very easily torn:—a Common Sea Snail (*Neoliparis*), Fig. CIX.

BUT IF: No notch in dorsal fin; sucking disc of variable size; skin of head and body rather soft and very easily torn:—see Section 2.

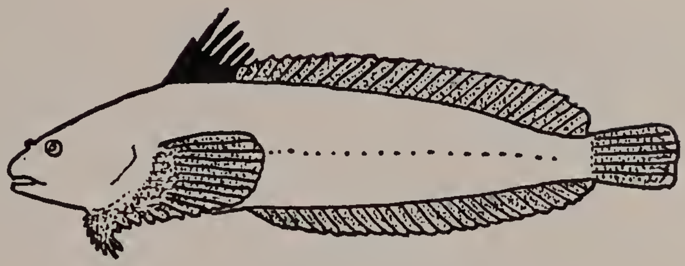
Section 2.

IF: Sucking disc large and flat, diameter about three times that of eye; longitudinal dark stripes on head and body:—a Striped Sea Snail (*Liparis*), Figs. VI and VII.

BUT IF: Sucking disc small and cup-like, diameter about equal to that of eye; colour of head and body uniformly whitish without stripes:—a Sea Tadpole (*Careproctus*).

[54] The recent revision of this family made by Burke (U. S. Nat. Mus. Bull., **150**, 204 pp. (1930)) has been very helpful in the preparation of this key.

Common Sea Snail,
Neoliparis atlanticus
Jordan and Evermann
1898
(Fig. CIX).



Not uncommon in the coastal waters of the whole region. Usually found among rocks, to which they are attached by their ventral sucking disc. Sometimes they attach themselves to lobster traps and are brought to the surface. Without economic importance. Grow to a length of about 5 inches.

Striped Sea Snail, *Liparis liparis* (Linnaeus) 1766 (Fig. VI).

Jones[19] reported the presence of this uncommon fish in our waters. Found in somewhat deeper water than the previous species. Maximum length about 6 inches.

Sea Tadpole, *Careproctus ranulus* (Goode and Bean) 1879.

In spite of the fact that this species was discovered for the first time in our waters near Chebucto Head, Halifax Harbour, in 52 fathoms, on September 24, 1877 (Goode and Bean[5], p. 276), no further records of its capture are known. Probably it is more northern in its distribution, as may be deduced from the bottom temperature of 35° F. where it was captured. Up to about 3 inches in length.

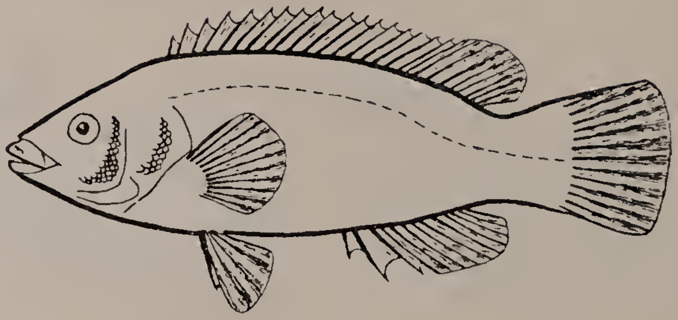
LXIX. CUNNER FAMILY, *LABRIDAE.*

Key for genera.

IF: Snout and top of head rounded giving a large angle profile; edge of cheek smooth not saw-toothed; gill covering largely naked; scales small, about 70 along lateral line; fish usually more than 15 inches in length:—a Tautog (*Tautoga*), Fig. CXI.

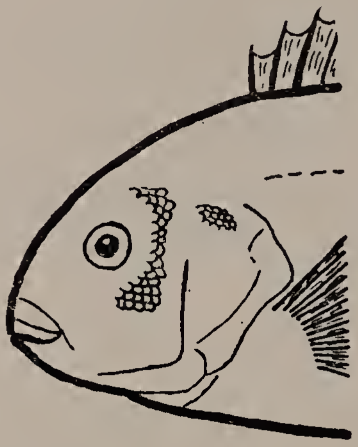
BUT IF: Snout and top of head rather flattened giving a small angle profile; edge of cheek saw-toothed; gill covering largely covered with scales; scales large, about 40 along lateral line; usually less than 10 inches in length:—a Cunner (*Tautogolabrus*), Fig. CX.

Cunner,
Tautogolabrus adspersus
(Walbaum) 1792
(Fig. CX).



Very common in the coastal waters of the whole region, being particularly abundant around fish wharves, among rocks and in kelp beds. Without economic importance, but is occasionally used as fish bait. Up to 15 inches in length and as heavy as 2½ pounds.

Tautog,
Tautoga onitis
(Linnaeus) 1758
(Fig. CXI).



There are only three positive records of the capture of this southern species in our region. Two specimens are exhibited in the Provincial Museum, Halifax, one of which was caught in Scott's Bay, Kings Co., July 12, 1902 (No. 950) and the other at Petpeswick Harbour, Halifax Co., May 12, 1903 (No. 1845). The third was caught at Cranberry Head, Yarmouth Co., in 1912, and reported by Fowler[55] (p. 517). Up to 3 feet in length and 15 pounds in weight.

LXX. SHARKSUCKER FAMILY, *ECHENEIDAE.*

Key for genera.

IF: Dorsal and anal fins long, practically equal in length, with 31 to 41 rays in each; sucking disc with 20 to 23 plates; a wide, dark, brown band along side on a brownish background:—a Large Sharksucker (*Echeneis*).

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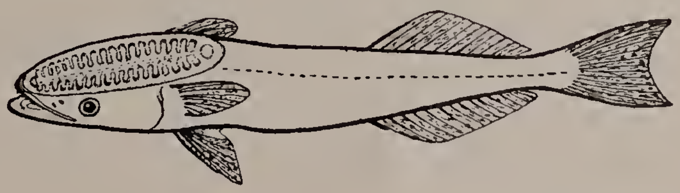
[55] Fowler. *Proc. Acad. Nat. Sci. Philad.*, **67**, 517 (1915).

BUT IF: Dorsal and anal fins short, with 20 to 25 rays each; sucking disc with 18 plates; colour uniformly dark blue without stripes:—a Blue Sharksucker (*Remora*), Fig. CXII.

Large Sharksucker, *Echeneis naucrates* Linnaeus 1758.

Rare, being an occasional visitor during the summer months. Many years ago, Jones[19] mentioned it among Nova Scotian fishes. Recently Leim[49] referred to another capture of a specimen 26½ inches in length, which was taken on a line trawl off Herring Cove, Halifax Harbour. Up to about 3 feet in length. All species of the Sharksucker family are pelagic fishes and are distributed throughout warm seas. In these fishes the first spiny dorsal fin is modified into a sucking disc by means of which they attach themselves to Sharks and other large moving objects. Even when the Shark is taken from the water they remain attached to it. In southern waters the natives sometimes use Sharksuckers to catch Sea Tortoises. Fastened on a line, the Sharksucker is released from the boat into the water close to the Sea Tortoise, to which it immediately attaches itself so firmly that the fisherman can, by pulling on the line, draw both the captor and its captive into the boat.

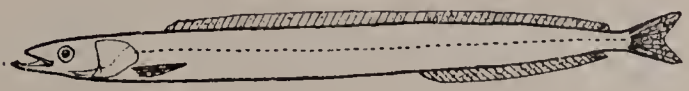
Blue Sharksucker,
Remora remora
(Linnaeus) 1758
(Fig. CXII).



This rare species was reported only recently for the first time from our region by Vladykov[15]. It is usually found attached to the Blue Shark (*Prionace glauca*). Grows up to 15 inches in length.

LXXI. SAND LAUNCE FAMILY, *AMMODYTIDAE.*

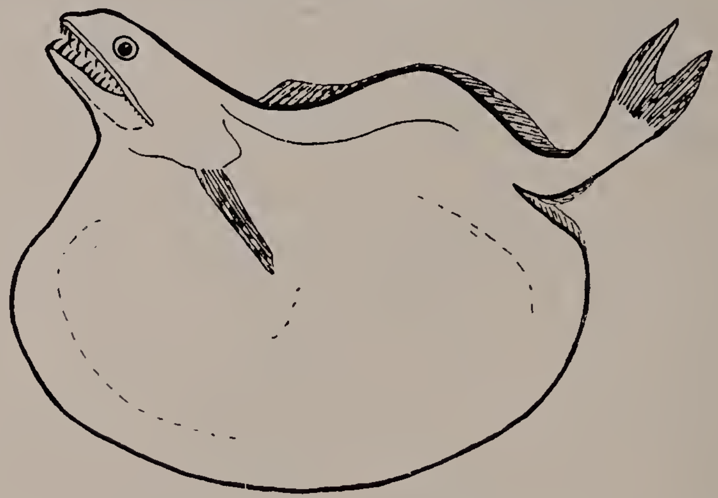
Sand Launce,
Ammodytes americanus
DeKay 1842
(Fig. CXIII).



Very common, particularly abundant over sand bottom on Western Bank. Without economic importance in our region. However, it plays an important part in the economy of the northern seas as food for fishes and larger animals. Cod, Haddock, Pollock, Halibut, Skates, etc., find it a staple article of food. Finback Whale also devour them greedily. The Sand Launce can burrow into the sand with great speed, thanks to their strong, pointed snout.

LXXII. BLACK SWALLOWER FAMILY, *CHIASMODONTIDAE.*

Black Swallower,
Chiasmodon niger
Johnson 1863
(Fig. CXIV).



This deep water fish very rare. Goode and Bean[5] (p. 292) refer to the capture of a specimen floating over Le Have Bank in June, 1880. Another specimen was taken just south of our region in 1932 (Vladykov[15]). This remarkable fish has sometimes been caught as deep as 1,500 fathoms. It has the ability to swallow fishes many times its own size through its large mouth and the great distensibility of the body walls. Our drawing represents a specimen containing a fish three times longer than itself. Grows up to about 1 foot in length.

LXXIII. BLENNY FAMILY, *BLENNIIDAE.*

The Blennies described herein are usually considered to belong to three families, but for the sake of simplicity they will be regarded here as belonging to a single family. These fishes, by their elongated snake-like body, may be confused with the Eel group, Ghostfish and Eelpout families. They differ from the first two in that they possess ventral fins, and from the last by the fact that the dorsal fin consists only of spiny rays and the caudal fin is clearly separated from both the dorsal and anal fins.

Key for genera.

Section 1.

IF: Ventral fin very small, less than one-fifth of length of pectoral fin; lateral line absent; at least 10 small, round, black spots along dorsal fin:—a Rock Eel (*Pholis*), Fig. CXV.

BUT IF: Ventral fin well developed, at least equal to one-third of length of pectoral fin; lateral line present or absent; dark spots on dorsal fin present or absent:—see Section 2.

Section 2.

IF: Body stout, depth not less than one-seventh of total length; caudal fin rounded:—see Section 3.

BUT IF: Body elongated, depth not more than one-tenth of total length; caudal fin slightly forked or pointed, not rounded:—see Section 4.

Section 3.

IF: Lateral line branched immediately behind head, lower branch running along middle of side for whole length of body, upper branch reaching only as far back as tip of pectoral fin; dorsal fin with less than 50 spines; a large, oval dusky blotch on anterior part of dorsal fin:—a Radiated Shanny (*Ulvaria*), Fig. CXVI.

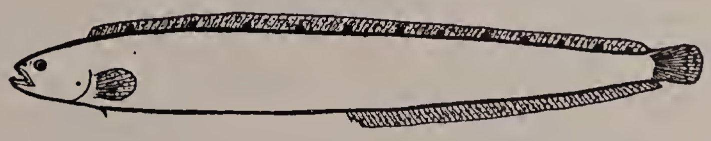
BUT IF: Lateral line single, running full length of body along side of back; dorsal fin with about 75 spines; usually 5 large, round, dark spots along dorsal fin:—an Arctic Blenny (*Stichaeus*).

Section 4.

IF: Pectoral fin notched, due to lower rays of fin being much longer than upper ones; margin of caudal fin straight or slightly forked; body depth not less than one-eleventh of total length:—a Common Shanny (*Leptoclinus*).

BUT IF: Pectoral fin not notched, lower rays of pectoral fin much shorter than upper rays; caudal fin pointed; body depth not greater than one-thirteenth of total length:—a Snake Blenny (*Lumpenus*).

Rock Eel,
Pholis gunnelis
(Linnaeus) 1758
(Fig. CXV).

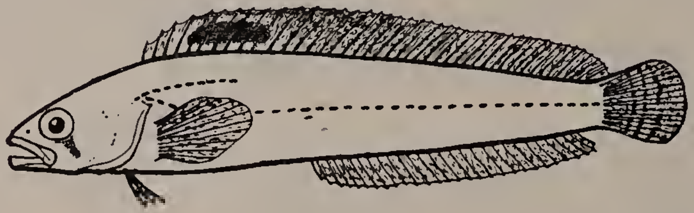


Common in inshore waters throughout the whole region. As its name indicates, it prefers to dwell among the rocks. Without economic importance. Often found in Cod stomachs. Up to 12 inches in length. In spite of its name "Eel", this fish has nothing in common with the true Eel except its shape.

Arctic Blenny, *Stichaeus punctatus* (Fabricius) 1780.

There have been only two specimens of this rare Arctic fish reported from our waters, and these were taken in Chedabucto Bay, near Canso, N. S. (Cornish[46], p. 87). Length up to about 7 inches.

Radiated Shanny,
Ulvaria subbifurcata
(Storer) 1839
(Fig. CXVI).



Rather uncommon, being reported from St. Mary Bay (Huntsman[26], p. 66) and around Canso (Cornish[46], p. 87) in water from 6 to 30 fathoms in depth. Length up to about 6 inches.

Common Shanny, *Leptoclinus maculatus* (Fries) 1837.

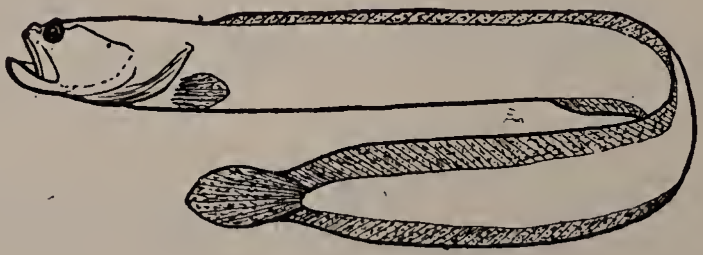
Only Jones[19] has listed this rare Arctic species among our fishes. However, no exact locality was given. Up to 7 inches in length.

Snake Blenny, *Lumpenus lampetraeformis* (Walbaum) 1792.

Huntsman[26] (p. 66) has reported the only capture of specimens of this northern species in our region, and these were taken in St. Mary Bay. Probably it may be found on Nova Scotian banks also, but no doubt this species is rather rare in our waters. Up to about 16 inches in length.

LXXIV. WRYMOUTH FAMILY, *CRYPTACANTHODIDAE.*

Ghostfish,
Cryptacanthodes
maculatus
Storer 1839
(Fig. CXVII).



This form rather common in coastal waters throughout the whole region. Probably during the winter months these fish withdraw to deeper waters. Through the courtesy of

Capt. F. Tidman (S. T. *Viernoe*), we have received two specimens of Ghostfish from Western Bank taken in about 60 fathoms of water, on January 21 and March 10, 1935. Without economic importance. Maximum length about 3 feet.

LXXV. WOLFFISH FAMILY, *ANARHICHADIDAE.*

Key for species of genus *Anarhichas.*

The following key is based on the comprehensive data by Gill[56].

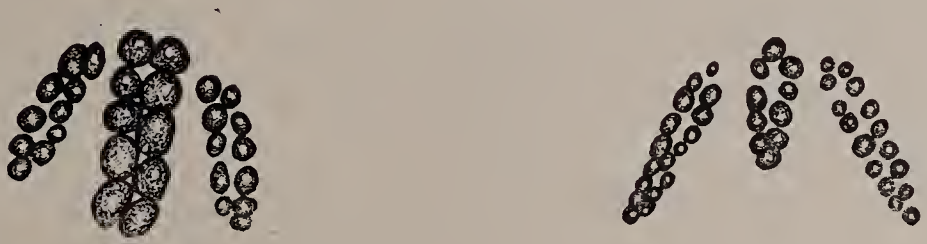


Fig. CXVIII—Types of teeth in two species of the Catfish family;

A.—*A. minor;* B.—*A. latifrons.*

Section 1.

IF: Vomerine teeth extending backwards only about one-half as far as palatine teeth (Fig. CXVIII B); colouration brown with obscure dark blotches, not with distinct dark cross-bands or spots:—a Broad-headed Catfish (*A. latifrons*).

BUT IF: Vomerine teeth extending farther backwards than palatine teeth (Fig. CXVIII A); distinct dark cross-bands or spots:—see Section 2.

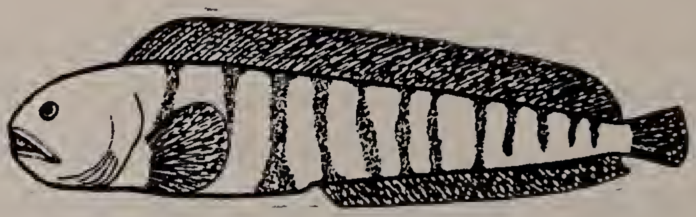
Section 2.

IF: 9 to 12 distinct dark cross-bands on side of body:—a Common Catfish (*A. lupus*), Fig. CXIX.

BUT IF: Head and body (lower surface excluded) together with dorsal and caudal fins covered with rounded, black spots on a yellowish background: —a Leopardfish (*A. minor*).

[56] Gill. *Proc. U. S. Nat. Mus.*, **39**, 157-187 (1911).

Common Catfish,
A. lupus
Linnaeus 1758
(Fig. CXIX).



Very common throughout the whole region in both coastal and bank waters. Of slight economic importance at present, with the annual catch amounting to about 133,000 pounds and valued at $4,500. It is an excellent table fish, growing to a maximum of 5 feet in length and 30 pounds in weight.

Broad-headed Catfish, *A. latifrons* Steenstrup and Hallgrimsson 1842.

Bean[14] (p. 82) for the first time reported the capture of this rare northern fish in our region, namely off Quereau Bank in 300 fathoms. Cornish[46] (p. 87) also mentioned the capture of a specimen off Canso in about 50 fathoms. Length about 5 feet.

Leopardfish, *A. minor* Olafsen 1774.

Rather rare. Bean[14] (p. 82) many years ago mentioned the capture of a specimen of this northern fish in 200 fathoms off Quereau Bank. The most recent capture in our region was made on the same Bank in 50 fathoms on November 5, 1934, by S. T. *Rayon d'Or* (Capt. H. S. Hansen) and reported by Vladykov[15]. Up to about 6 feet in length. In Europe the skins of this species, as well as of other Catfishes, are used for making ladies' purses, book covers, etc.

LXXVI. EELPOUT FAMILY, *ZOARCIDAE.*

These fishes are easily separated from the Blennies as the dorsal fin consists of soft rays only, or at the most, has only a few spines in the posterior part, while in the Blennies this fin is entirely spiny-rayed. Moreover, in the Eelpout family, there is no line of demarcation between the dorsal, anal and caudal fins, which, are continuous around the posterior part of the body. The latter character, as well as the fact that the dorsal fin is usually composed of soft rays, makes this family quite similar to the Eel group. The Eelpouts, however, are easily distinguished from the Eels by possessing small ventral fins, located on the lower surface in front of the pectoral fins and immediately behind the isthmus. A single exception to this rule, however, exists in the Green Eelpout, which has no ventral fins, and thus is still more similar to the Eel group. The Green Eelpout (Fig. CXXIV), by having the gill opening above the base of the pectoral fin, thick lips, long pectoral fins and a rather stout body, may be readily distinguished from the Eels. Because of the great degree of similarity between the Eels and the Green Eelpout, the latter has been separated from the other Eelpouts and placed next to the Eel groups in the General Key.

Key for genera.

IF: Ventral fins absent:—a Green Eelpout (*Gymnelis*), Fig. CXXIV.
BUT IF: Ventral fins present:—see Section 2.

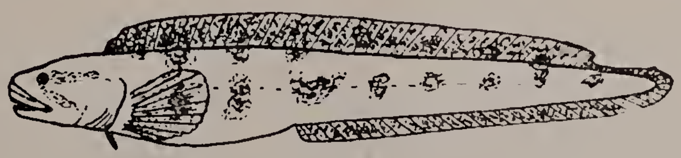
Section 2.

IF: Dorsal fin in its posterior part consisting of very short spines, giving impression of a gap between long dorsal rays and caudal fin:—a Common Eelpout (*Zoarces*), Fig. CXX.
BUT IF: No short spines, consequently no appearance of a gap between dorsal fin and caudal fin:—see Section 3.

Section 3.

IF: Body stout, depth not less than one-thirteenth of total length, dorsal fin beginning close to head above middle of pectoral fin:—an Arctic Eelpout (*Lycodes*), Fig. CXXI.
BUT IF: Body snake-like, depth not more than one-sixteenth of total length; dorsal fin beginning farther from head, over tip of pectoral fin or slightly in front, not over middle of this fin:—a Wolf Eel (*Lycenchelys*), Fig. CXXIII.

Common Eelpout,
Zoarces anguillaris
(Peck) 1804
(Fig. CXX).



Very common throughout the whole region, both in coastal and "bank" waters. Although its flesh is of a very good quality, it is, as yet, without economic importance in this country. The European species is a well known commercial fish. Maximum length about 4 feet and weight about 12 pounds. This fish is well known to our fishermen, but under the name "Conger Eel", for it is found often in lobster traps or caught on baited hooks.

Key for species of genus *Lycodes*.

The exact number of *Lycodes* species found in North American waters is, as yet, unknown. In our list we follow, in part, the data given by Bean[14], and Goode and Bean[5], in the light of the critical remarks made by A. S. Jensen[8]. The distinction between the species of the Arctic Eelpout is very difficult and consists in different development of the lateral line which may be single or double, and situated in various positions along the side; the number of rays in the dorsal and anal fins; the length of the tail (the distance from the anus to the posterior tip of the fish); and the degree to which the belly and anterior part of the trunk are covered with scales. All these characters require particular attention for correct identification, and are applicable for specimens not smaller than 5 inches in length, while correct identification of small specimens by the non-specialist is almost impossible. The following key is principally based on the excellent monograph on "The North-European and Greenland *Lycodinae*" by A. S. Jensen[8].

Section 1.

IF: Lateral line single, running along middle of side; tail short, usually slightly less than one-half of total length; belly and anterior part of back naked (in front of dorsal); number of rays in dorsal and anal fins less than 95 and 80 respectively; 7 to 9 dark cross bands on trunk and tail, which may form a network pattern in older specimens:—an Arctic Eelpout (*L. reticulatus*), Fig. CXXI.

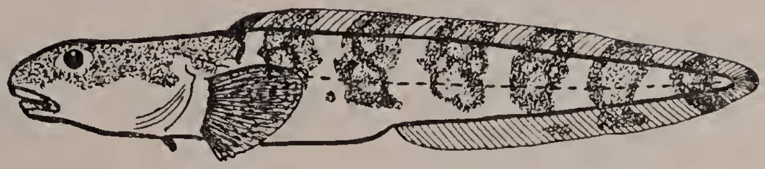
BUT IF: Lateral line single or double and at least one of them running along lower part of side; tail longer, more than one-half total length; entire body covered with scales; number of rays in dorsal and anal fins more than 95 and 80 respectively; colouration variable:—see Section 2.

Section 2.

IF: Lateral line single, running along lower edge of side; body in larger specimens with or without dark cross bands; dark patches (1 to 3) on anterior part of dorsal fin:—a Vahl's Eelpout (*L. vahlii*), Fig. CXXII.

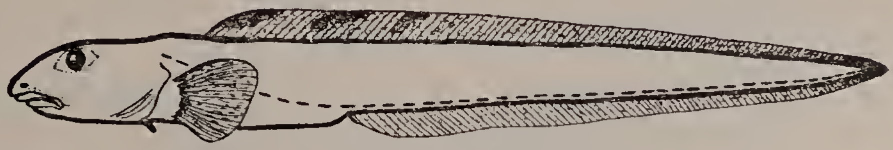
BUT IF: Lateral line double, more distinct one running along lower edge of side, the other, along middle of side; body dark with 5 to 9 whitish yellow cross bands; no black patches on anterior part of dorsal fin:—an Esmark's Eelpout (*L. esmarkii*).

Arctic Eelpout,
L. reticulatus
Reinhardt 1838
(Fig. CXXI).



This is usually believed to be the most common *Lycodes* in our waters, frequenting depths around 50 fathoms. Without economic importance. Maximum length about 2 feet. This, as well as the following species of this genus, is not frequently captured in our region, because of the habit of living close to the bottom in relatively deep water.

Vahl's Eelpout,
L. vahlii
Reinhardt 1838
(Fig. CXXII).



Goode and Bean[5] (p. 308) have recorded the capture of this species on the Nova Scotian banks (Quereau Bank) in 130 to 190 fathoms. Length about 1½ feet.

Esmark's Eelpout, *L. esmarkii* Collett 1875.

According to Goode and Bean[5] (pp. 303-305) this species has been taken on Le Have Bank and in the Bay of Fundy in depths of 224 to 400 fathoms. Maximum length slightly more than 2 feet.

Key for species of genus *Lycenchelys.*

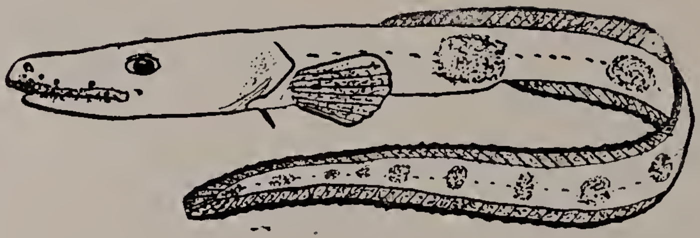
IF: Dorsal and anal fins long, with 118 and 110 rays respectively; scales covering entire body; nearly all vertical fins and body uniformly brownish; head dark:—a Common Wolf Eel (*L. paxillus*).

BUT IF: Dorsal and anal fins shorter, with 92 and 88 rays respectively; scales rather scarce upon lower half of body and none on anal fin; colour greyish with irregular brown patches:—a Verrill's Wolf Eel (*L. verrillii*), Fig. CXXIII.

Common Wolf Eel, *L. paxillus* (Goode and Bean) 1879.

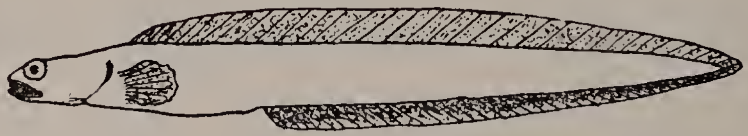
This fish is probably not uncommon in the deeper gullies between the Nova Scotian banks. Goode and Bean[5] (p. 311) discovered this fish for the first time in the gully between Le Have and Sable Island Banks at a depth of 200 to 400 fathoms. Without economic importance. Maximum length about 1 foot.

Verrill's Wolf Eel,
L. verrillii
(Goode and Bean)
1877
(Fig. CXXIII).



This is possibly a rarer species than the Common Wolf Eel. According to Bigelow and Welsh[3] (p. 382) "it is known from the fishing banks off the outer coast of Nova Scotia, off Cape Negro and off Halifax (90 to 101 fathoms)." Grows to about 10 inches in length.

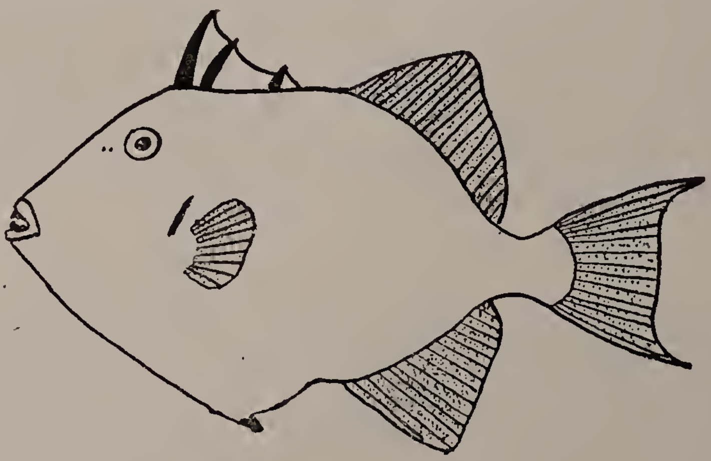
Green Eelpout,
Gymnelis viridis
(Fabricius) 1780
(Fig. CXXIV).



This Arctic species is no doubt very rare, although several authors have listed it among Nova Scotian fishes. However, none of them has given any definite records of its capture in our region. They usually just repeat the statement of Goode and Bean[5] (p. 313) that "this species has been found in abundance in the Arctic Seas from Alaska to Nova Scotia." In northern waters it reaches about 10 inches in length.

LXXVII. TRIGGERFISH FAMILY, *BALISTIDAE.*

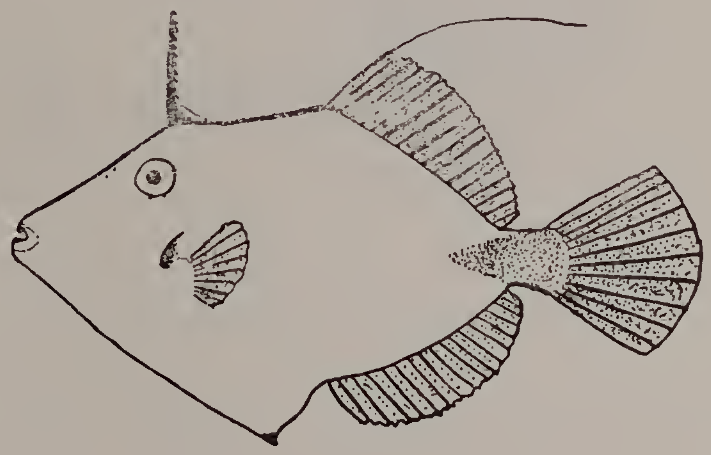
Triggerfish,
Balistes capriscus
Gmelin 1788
(Fig. CXXV).



This southern form is only occasionally found during the summer months in both the coastal and "bank" waters of the outer coast of Nova Scotia. Vladykov[15] summarized the data on its occurrence in our region. Maximum length about 1 foot.

LXXVIII. FILEFISH FAMILY, *MONACANTHIDAE.*

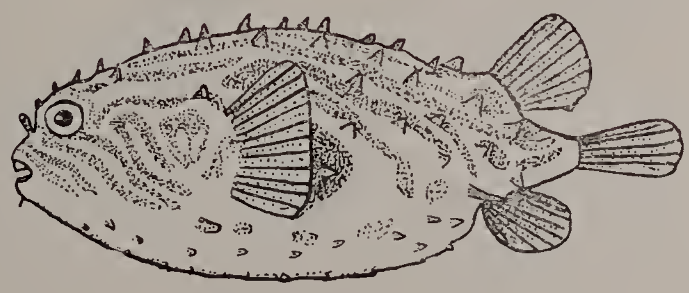
Filefish,
Monacanthus hispidus
(Linnaeus) 1766
(Fig. CXXVI).



This tropical fish is similar to the preceding species in its occurrence in our region. Maximum length about 10 inches. The name is derived from the file-like dorsal spine. The rough, hard skin, formerly at least, was used as an abrasive in a manner similar to sandpaper.

LXXIX. PORCUPINEFISH FAMILY, *DIODONTIDAE*

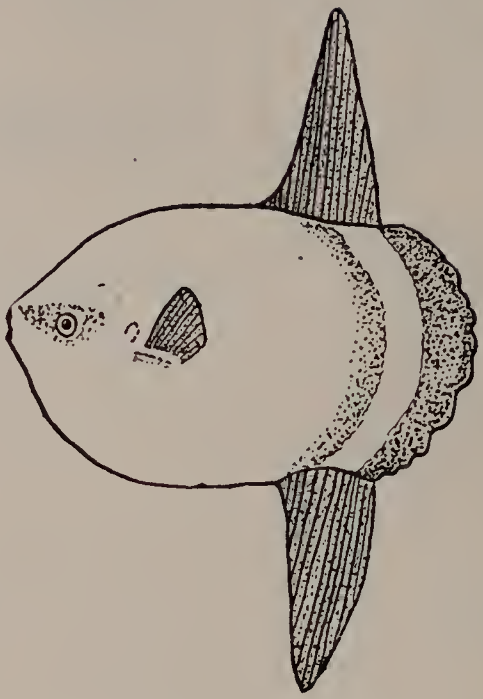
Burrfish,
Cyclichthys schoepfi
(Walbaum) 1792
(Fig. CXXVII).



Piers[16a] (p. 110) first mentioned the capture of a specimen of this rare southern fish in our waters, namely off Sambro, near Halifax, in the summer of "about 1896." Attains a length of about 10 inches.

LXXX. SUNFISH FAMILY, *MOLIDAE.*

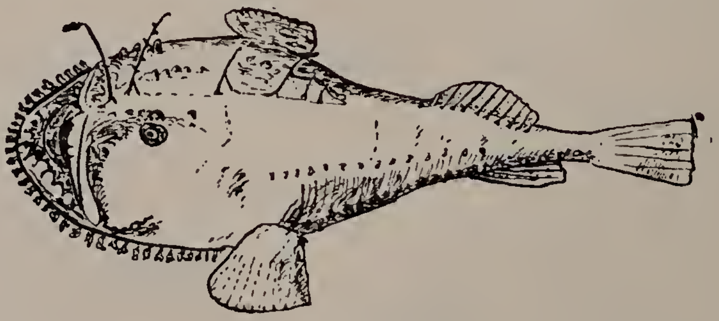
Sunfish,
Mola mola
(Linnaeus) 1758
(Fig. CXXVIII).



A regular summer visitor to both shore and "bank" waters of the outer coast of Nova Scotia. Usually swims close to the surface. Without economic importance. Grows up to 11 feet in length and a ton in weight.

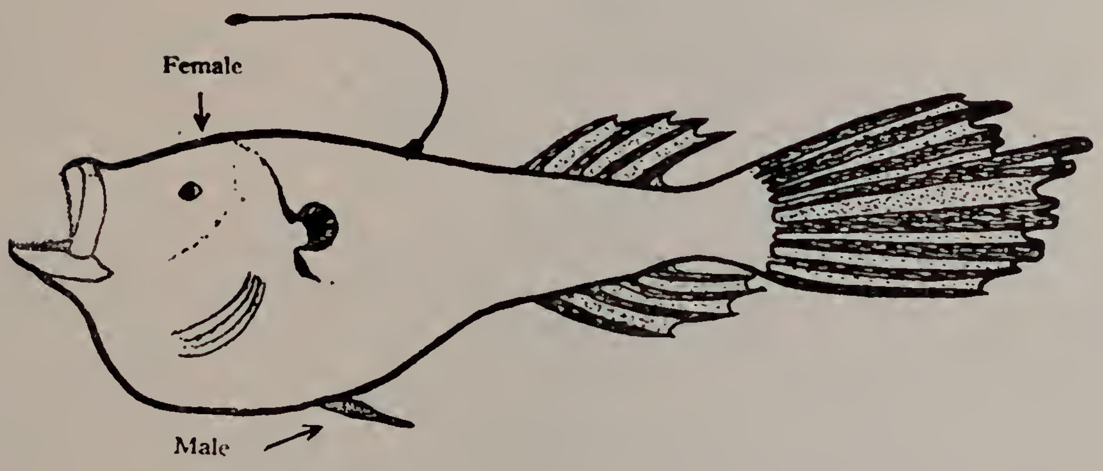
LXXXI. ANGLER FAMILY, *LOPHIIDAE.*

Monkfish,
Lophius piscatorius
Linnaeus 1766
(Fig. CXXIX).



Very common on the "banks", and frequently found in the coastal waters of the whole region. Of slight economic importance, being used only recently in the making of fish meal. In Europe, however, it is a regular marketable fish. Up to 4 feet in length and 70 pounds in weight. Its appetite is almost proverbial, as it feeds on a number of fishes, lobsters, crabs, etc. Even sea birds (gulls, loons, ducks, etc.) do not escape its mouth, hence the name of "Goosefish" used in some places.

LXXXII. SEA DEVIL FAMILY, *CERATIIDAE.*



Sea Devil, *Ceratias holbolli,* Krøyer 1844 (Fig. CXXX).

According to Goode and Bean[5] (p. 489), one specimen of this remarkable deep water fish has been taken "off Nova Scotia" (exact location not given). Length up to about 2 feet. The drawing (Fig. CXXX) represents a female with a curious appendage attached to her throat which is a diminutive male of the same species, fully adult and apparently the mate of the relatively gigantic female. The discovery and description of these parasitic males was recently made by Regan[57].

[57] Regan. *Proc. Roy. Soc. London,* (B) **97** (1925) and the "*Danish Dana Expedition*", 1920-22. Oceanogr. Rept. No. **2**, Copenhagen, 1926.

THE GOLDENVILLE-HALIFAX BOUNDARY AT FAIRVIEW, N. S.

ELIZABETH KING
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(Received May 26, 1935).

ABSTRACT

At the boundary between the Goldenville and Halifax formations at Fairview, N. S., there has been found a bed of impure limestone. This is a continuation of the long-known limestone bed on the other limb of the Dartmouth syncline at Preston. Several other beds of limestone below the first have been discovered. At the surface the limestone has been decomposed, leaving a porous rock containing manganese dioxide. The limestone deposits are probably concretionary. Water-worn pebbles were found in the quartzite, but only near the boundary and there sparingly. We make the suggestion that these pebbles were dropped by floating ice in the interval between the deposition of the Goldenville and Halifax sediments.

Two summers ago I found a limestone pebble on Dutch Village Road, and later found another further north on the same road. Probably these pebbles are of glacial origin. Though limestone is found in Hants County, my samples had not travelled far because they were little worn and limestone is comparatively soft. J. W. Goldthwait[1] said that, because of their shortness, trails of the softer rocks do not demand such extensive field studies. Glacial striae in this region show that the glacier came from 30-40° W. E. R. Faribault[2] reported limestone at Preston and at Southeast Passage. W. Malcolm[3] said that limestone has been seen at two points at the base of the Halifax formation. "On the shore at Southeast Passage P. O. it is found in a crystalline state interstratified with quartzite in a belt several feet thick. A bed 3 feet thick is found at the same horizon near Preston Road P. O. and was burned by the early settlers for lime. Almost anywhere east of Halifax, effervescence with acid shows the presence of calcium carbonate in a few beds at the base of the formation."

Though this limestone has not been reported from in or west of Halifax, the above facts led me to explore the boundary. This was found exposed (1) on the property of Mr. A. E.

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[1] Goldthwait, *Canada Dept. of Mines, Geol. Survey*, Memoir No. **40**, 75 (1924).
[2] Faribault, *Geol. Survey Map, City of Halifax Sheet*, No. **68**.
[3] Malcolm, *Canada Dept. of Mines, Geol. Survey*, Memoir No. **20**, 53 (1912).

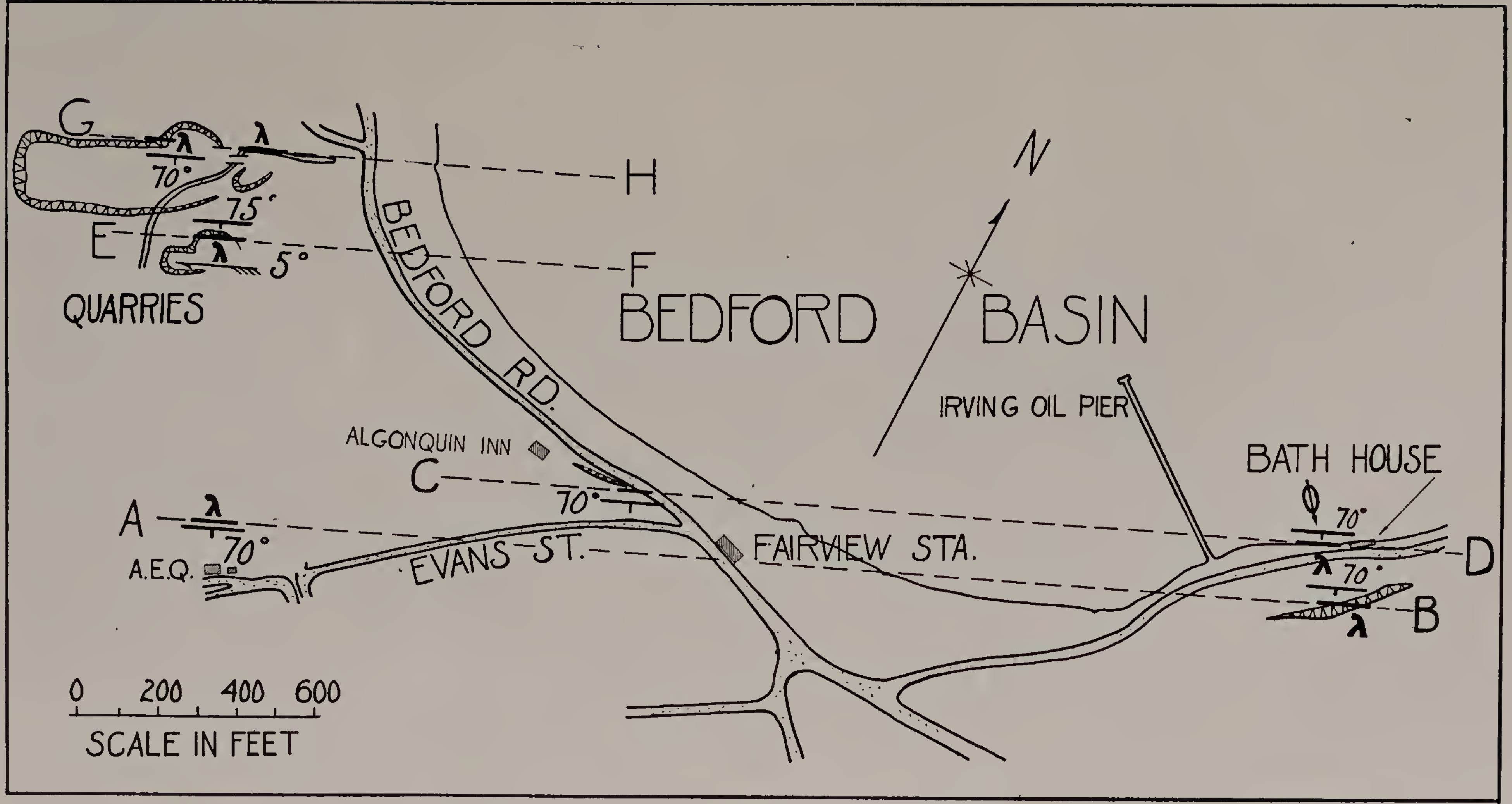

Fig. 1. Map of Fairview Region Showing Boundary and Limestone Beds.

Quaintance on Evans Street Extension, Fairview, (2) to the south of the bathhouse on the property of the Irving Oil Co., Ltd., and (3) at the crossing of Robie and Leeds Streets and to the south of Rockhead Prison. Most of my field work was in the Fairview region which is only about 1.5 miles from home. The boundary crosses the Bedford Basin as shown by line AB on Fig. I., though on the Geological Survey Map, Sheet No. 68, it is 0.1 mile to the south. The Halifax formation near the boundary consists of a uniform slate carboniferous with distinct cleavage. At the boundary there is an abrupt change to a series of alternating beds of quartzite and slate showing prominent cross-bedding.

The area shown on the map is between the Dartmouth syncline on the south and the Birch Cove anticline on the north. The strata dip to the south with an angle of 70-75°. In the southern quarry at E there is a curious cave-like structure out of which flows water. The bedding planes have a dip to the south of 75°. The roof resembles the barrel structure at Waverley and at first sight looks like the top of an anticline. The roof slopes 113° W. with a plunge of 5°.

Throughout this region the granite intrusion must have been very near the surface. In Maxwell's quarry the slate and quartzite have a conchoidal fracture similar to that at known granite contacts to the southwest of Halifax. Quartz veins cut the strata just to the south of Algonquin Inn at right angles to the strike. Near these veins there has been a deposition in the rocks of silica from solution. This is similar to a case found to the northwest of Governor Lake.

Interbedded in these highly metamorphosed sedimentaries are found at least four beds of limestone. These are at points marked λ on the map. Other beds of limestone probably are present. For instance, a bed to the west of Rockhead Prison points to a little north of Algonquin Inn but could not be found there because of glacial drift. Here and there in the quartzite small nodules of limestone are found, which do not seem to belong to any special bed.

The limestone is very impure, appearing similar in color to the surrounding rock. The two southern beds are grayish-black while the two northern ones are pale gray. The limestone rock effervesces freely with hydrochloric acid but does not disintegrate. Directed by Dr. King, I found that the limestone contains ferrous and manganous carbonates, graphite and only traces of magnesium.

Where long exposed the limestone has been dissolved out leaving a porous, brown to black decomposition product. This material makes the location of limestone deposits easy. The color is largely due to manganese dioxide because chlorine is given off when the rock is moistened with warm hydrochloric acid. On the shore, where washed by the waters of Bedford Basin, the color is nearly black. Large lumps of this material taken from the bed on the Quaintance property contain inside residual nodules of limestone. The surrounding decomposition product is banded.

Similar bands are observed in the quartzite surrounding the limestone nodules in the bed at G in Maxwell's quarry. The nodules lie in an almost continuous bed in quartzite between thin beds of slate. This mode of occurrence probably indicates concretionary origin. Before the granite intrusion part of the limestone was dissolved out. The surrounding decomposition material was banded, and these bands remained even after intense metamorphism by the granite intrusion. The appearance of a small fault, with a displacement of only a fraction of an inch, cutting both limestone and quartzite, shows that solution took place before metamorphism by the granite intrusion.

At several points water-worn pebbles are found sparingly in the quartzite near the limestone beds. One of these pebbles, a flat stone, was strongly bent without breaking. These pebbles are not segregated in heaps but occur separately. Therefore it is not probable that they were carried by water. We make the suggestion that these pebbles were dropped by ice in the period between the deposition of the Goldenville and Halifax sediments. A similar case of recent occurrence was found at Clementsport, N. S. Some time ago samples of a glassy material, supposed to be obsidian, were sent to the late Prof. D. S. McIntosh. He asked us to find more material in this locality. We found it on the bank of Moose River in a slag heap of the old Cunard Iron Works. Pieces of this slag had been picked up by ice and transported up and down Annapolis Basin.

Through the courtesy of Messrs. A. E. Quaintance and Edward Maxwell I was able to procure valuable specimens and data on their properties. The clinometer used was a much appreciated gift from Professor G. V. Douglas. Finally, I wish to acknowledge the help of Dr. H. S. King who supervised both the field work and the writing of this paper.

A NOTE ON THE USE OF HOT WIRE ANEMOMETERS.*

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Fisheries Exp. Sta. (Atlantic), Halifax, N. S.

(Received July 20, 1935).

ABSTRACT.

The constant temperature hot wire anemometer must be used in the position of calibration when measuring very low air speeds. This was shown to be necessary on account of the difference in form of the calibration curves. The self-induced air currents vary with the position of suspension of the instrument.

An investigation on the effect of change in variables in the pretreatment and smoking of fish required the measurement of gas velocities varying between 1 and 500 cm./sec. The hot wire anemometer of the constant temperature type was the most suitable instrument for this work.

The calibration of several anemometers at very low velocities led to an observation that had not hitherto been considered.

E. Ower and F. C. Johansen[1] reported negative readings of the equlibrium current with a minimum, depending on the temperature of the wire, at about 3 cm./sec. Certain inexplicable discrepancies in zero readings of one anemometer used by the authors resulted in the postulate that the relation between these negative readings and the velocity of flow past the wire depended on the position of use of the anemometer, the wire being held normal to the air stream in all cases. This was shown to be the case.

One typical wire operated at a temperature of about 200°C. was examined in several positions. In the horizontal position (1, Fig. I.) negative readings commenced at a velocity of zero and continued to approximately 6 cm./sec. The same wire used in the vertical position (2, Fig. I) showed a lower zero, and negative readings too small for detection with the instruments available. If extrapolation of the curve in the manner shown be justified, negative readings commence at

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[1] Ower, E. and Johansen, F. C., "*Pitot-static tube factors at low Reynold numbers.*" Aero. Research. Comm. Repts. and Memo. No. 1437, **Aug. 1931.** H. M. Stat. Office, London.

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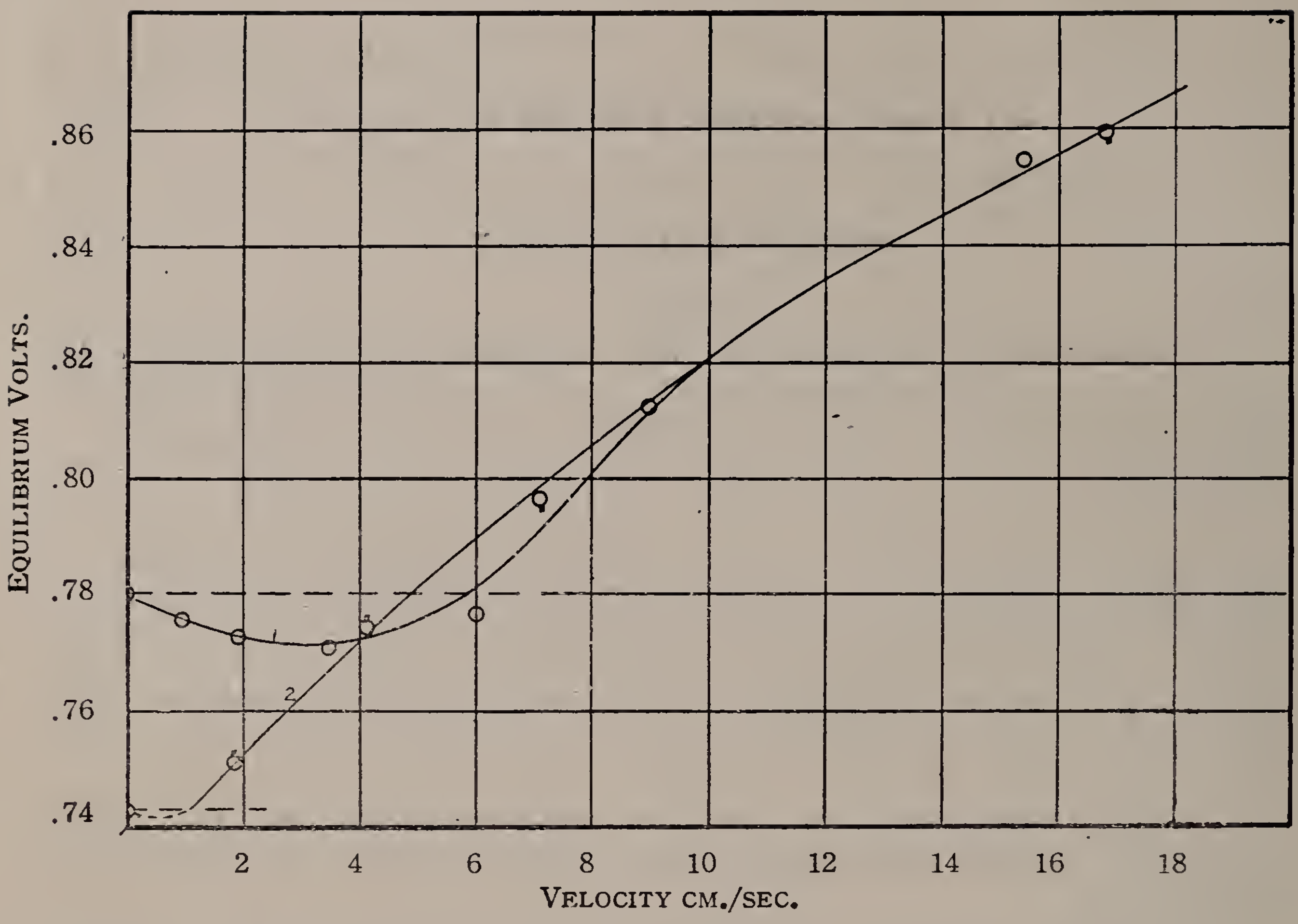

zero and continue to approximately 1 cm./sec. In Fig. I the velocity of air flow normal to the wire is plotted as abscissae. The ordinates represent the voltage drop across a standard controlling resistance in the arm of the Wheatstone bridge circuit opposite to that containing the anemometer.

The following explanation is offered to account for the difference in the nature of the curves. King[2] has shown that hot wires induce air currents about themselves. That negative readings are a function of the relative speeds of these induced currents and the normal speed of the air has been suggested by Ower and Johansen to explain the negative readings obtained with their instruments. That position of the wire in which it is vertical, but still normal to the direction of air flow used subsequently for calibration, induces smaller air currents approximately parallel to the wire. Hence positive readings would be expected to occur at lower air speeds. The curves coincide at approximately 10 cm./sec. At this point the self-induced currents become negligible in comparison with the velocity of gas normal to the wire.

[2] King, L. V. see Ower E. *"Measurement of Air Flow."* 2nd. ed. chap. X, Chapman and Hall, London **1933.**

THE EARLY DEVELOPMENT OF THE CHONDROCRANIUM OF *SALMO SALAR.*

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(Received July 22, 1935).

ABSTRACT.

150 *S. salar* embryos were studied by van Wijhe's technique. 14 stages, from 3 weeks before hatching to 10 weeks after hatching, were used. Results: The parachordal and trabecula arise independently. No separate anterior centre of chondrification was found for the parachordal as described by Stöhr. It may sometimes arise in this way, but is probably exceptional. The hyomandibula and symplectic arise separately and later join. Meckel's cartilage arises independently. The otic capsule first appears in the region where the hyomandibula will become attached to it lateral to the anterior end of the parachordal. The quadrate arises independently and about 5 weeks later the upper jaw develops from it as an outgrowth, the pterygoid process. The stylohyals, ceratohyals, hypohyals and basihyal arise as separate cartilages. The stylohyals are the last of the group to appear. The ceratobranchials and hypobranchials arise as separate cartilages. The fifth branchial arch has no hypobranchials and its ceratobranchials remain relatively poorly developed. Four epibranchials and all the pharyngobranchials studied (the first three) arise as separate cartilages. The copula is a single median structure usually divided into two segments. The first three branchial arches are associated with the anterior of these, the fourth and fifth branchial arches with the posterior. The taenia marginalis arises independently and finally joins the otic capsule and ethmoid plate. The epiphysial bar grows medially from the taenia to fuse with its fellow from the other side, and thickens to form the tectum which roofs over the anterior part of the skull. The ethmoid plate forms medially by a union of the anterior ends of the trabeculae. The interorbital septum grows up from the centre and a lamina orbitonasalis from each side. The former joins the median process, while the latter joins the lateral process of the taenia. To show the rate of cartilage development morphologically 3 curves were made from the drawings, by plotting against time: (1) the number of new cartilages appearing each day; (2) the total area of cartilage in the head; and (3) the ratio of cartilage area to head area. All showed a falling off in cartilage development at the time of hatching. A possible explanation for this cessation of development is that energy which was being used in building new material has been diverted to the arduous task of hatching.

INTRODUCTION.

No detailed account of the skull development of *Salmo salar* has been given since Parker[1] described the early stages. His work was reviewed and enlarged upon by Stöhr[2] who, however, added very few illustrations. Gaupp[3] summarized existing knowledge and included drawings of three models. His is the most recent work on early development although the later development of the skull is well known. This paper reports the results of a re-examination of the early development attempting to clear up the following points, none of which are adequately dealt with in any preceding publication: the origin and progressive development of the cartilages; the manner in which the cartilages unite; the relationship of the developing visceral arches.

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[1] Parker. *Phil.Trans. Roy. Soc.* **163,** 95, (1873).

[2] Stöhr. *Festschr. der J. Max. Wurzburg,* **2,** pp. 73-93, (1882).

MATERIALS AND METHODS.

Several batches of eggs were obtained two days after fertilization from the Government Fish Hatchery in Bedford, N. S., and were kept in a tank of running water at a constant temperature of approximately 5°C. The eggs hatched from 41 to 60 days after fertilization, depending on the temperature of the water. Each week, or more frequently in younger stages, 10-15 eggs or embryos were removed from the tank for fixation in Bouin's fluid. After hardening, and removal of the yolk sac (and shell where necessary), they were stained by van Wijhe's[4] method. Van Wijhe's stain contains 1% hydrochloric acid, which destroys most of the tissues leaving the cartilage to stand out clearly in blue. Benzyl benzoate, which was adopted as a clearing fluid and permanent preservative, has marked advantages over other agents. It clears with exceptional speed and effectiveness, making the stained cartilaginous parts stand out with great clarity, and it prevents brittleness, thereby permitting easy slicing with a razor blade when necessary. A complete set of whole mounts was obtained using this method.

Every embryo in each sample was examined, in order to be sure that the one used in the figure was typical. When any difference was noted, examples of each have been drawn.

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[3] Gaupp. Hertwig's *Handbuch der Entwicklungslehre der Wirbeltiere*, Verlay von Gustav Fischer, Jena, **906**, p. 660.

[4] Lee. "*The Microtomist's Vade-mecum,*" P. Blakiston's Son & Co., Philadelphia, **1928**, p. 920.

Early attempts to make drawings with the aid of a camera lucida were abandoned in favour of the following method which was easier and more accurate. A squared eye-piece micrometer was inserted into the microscope and calibrated with a stage micrometer. Drawing paper was squared to correspond at a magnification of 40. When the embryos were examined under the microscope, they appeared with the eye-piece squares superimposed. The embryos could then be drawn to fit into the corresponding squares on the paper. To facilitate drawing and to observe the cartilaginous structures more clearly, median sagittal sections were made of the heads of the larger embryos and the eyes were removed. Hand sections were made in a few cases, separating the visceral arches from the neurocranium. These sliced embryos were compared carefully with intact specimens.

DESCRIPTION.

The following is a description of the significant stages in the development of the chondrocranium. The nomenclature follows closely that used by de Beer[5] in a similar paper on the development in the trout. It has been found simpler to describe the developmental condition in terms of the number of days before and after hatching, rather than with reference to the number of days after fertilization.

Fig. I. Embryo H1A. 21 days before hatching. This is the earliest specimen in which cartilage shows. The first structures to appear are paired cylindrical rods, the parachordals, which arise in the posterior region of the head on either side of the notochord. There is a dense enlarged region at the posterior ends which will later give rise to the occipital arches. Each of the parachordals arises from a single centre of chondrification. None of the specimens observed showed a separate anterior centre of chondrification, as was described by Stöhr[2]. De Beer[5] does not find any separate anterior centre in the trout and he suggests that Stöhr's specimens may have been exceptions.

[5] de Beer. *Quart. Journ. Micr. Sci.* **71**, 259, (1927).

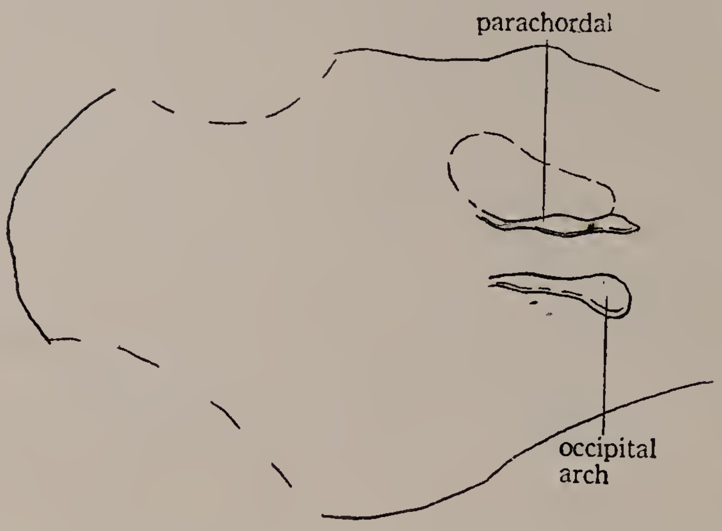


Fig. I. Embryo H 1A, dorsal view (21 days before hatching).

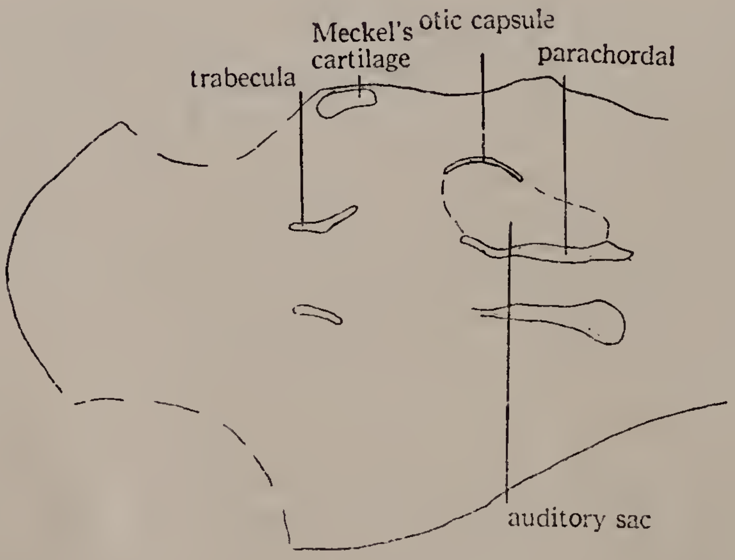
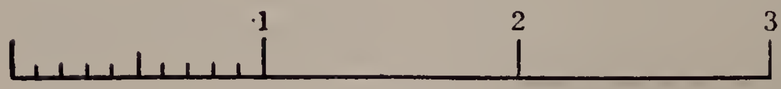


Fig. II. Embryo H 1B, dorsal view (21 days before hatching).



Scale-mm.

Figures I. to XX. are drawn to the above scale.

Fig. II. Embryo H1B. 21 days before hatching. The parachordals have not grown any larger but they are more thoroughly chondrified. Several new cartilages appear. The trabeculae arise as small rods, anterior to and slightly more ventral than the parachordals. They are curved outward around the future hypophysial fenestra. Meckel's cartilage may be distinguished as a knob, at the outer posterior border of the mandibular arch. A small portion of the otic capsule has progressed to procartilage.

Fig. III (a and b). Embryo H3A. 21 days before hatching. The trabeculae have lengthened, and in lateral view, the posterior ends are on a level with the parachordals, though still distinctly separated from them. The occipital arches are arising at the posterior ends of the parachordals. The visceral arches also show considerable development. Meckel's cartilage is more dense, and above it the quadrate and symplectic appear, one behind the other. The hyomandibula and otic capsule arise close together, lateral to the anterior end of the parachordal.

Fig. IV. Embryo H3B. 21 days before hatching. The trabeculae have joined the anterior ends of the parachordals, thus forming two supporting rods extending under the brain. Three new visceral arches have appeared. The ceratohyals originate as short paired rods posterior to Meckel's cartilages. Behind them, the ceratobranchials of the first and second branchial arches appear.

Fig. V. Embryo IA. 14 days before hatching. Meckel's cartilages have extended well forward into the mandibular arch, but they do not meet. The ceratohyals are longer and more thoroughly chondrified; median to the anterior ends two small cartilages, the hypohyals, have arisen independently. The first two ceratobranchials have elongated, and behind them the ceratobranchials of the third and fourth branchials appear. The cartilage of the quadrate is more dense and the hyomandibula and symplectic are joined by a thin layer of cartilage.

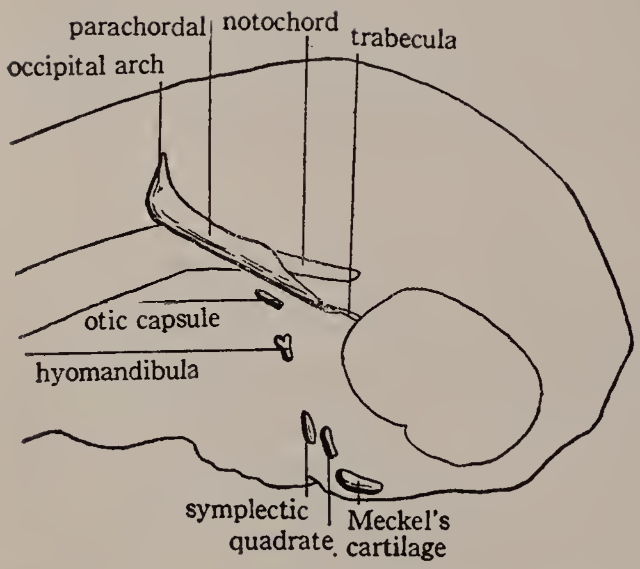


Fig. III (a). Embryo H 3A, lateral view (21 days before hatching).

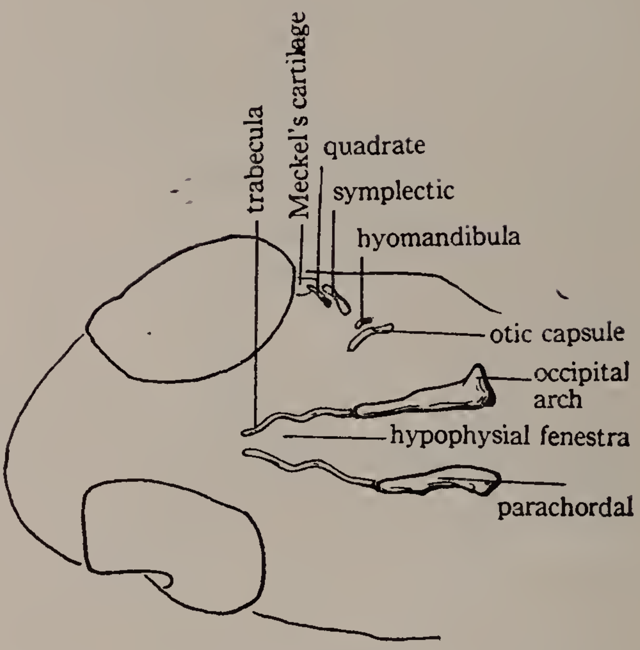


Fig. III (b). Embryo H 3A, dorsal view (21 days before hatching).

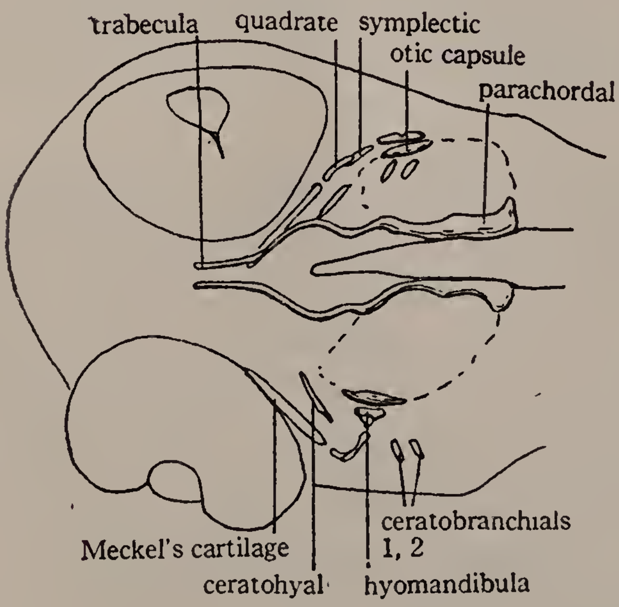


Fig. IV. Embryo H 3B, dorsal view (21 days before hatching).

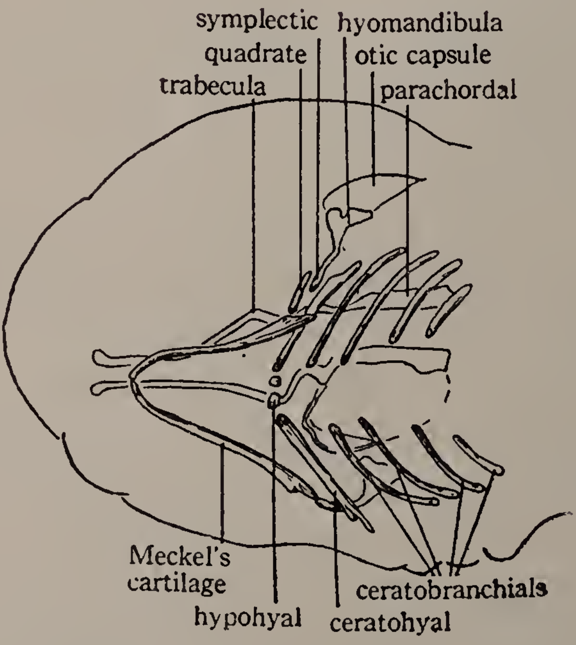


Fig. V. Embryo I A. ventral view (14 days before hatching).

Fig. VI. Embryo IB. 14 days before hatching. The trabeculae have extended forward almost to the front of the head, at the same time widening at the anterior ends. The otic capsules have been joined to the parachordals, anteriorly by the anterior basicranial commissure, and posteriorly by the posterior basicranial commissure. The enclosed space is the basicranial fenestra. The occipital arches have grown upward considerably, leaving a space between them and the otic capsules, which will later be closed off as the jugular foramina. The visceral arches are little changed. The connection between the hyomandibula and symplectic is complete and the copula appears as a small median cartilage directly behind the hypohyals.

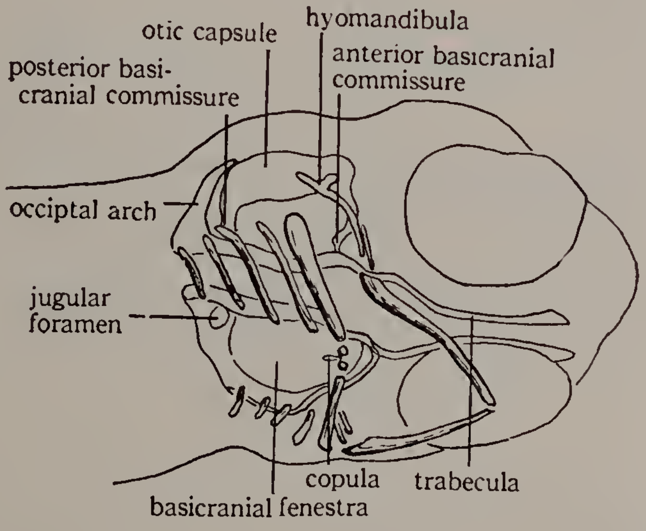


Fig. VI. Embryo I B, ventral view (14 days before hatching).

Fig. VII (a and b). Embryo 6. 14 days before hatching. The size has increased, and the prootic process, a slight prominence at the anterior border of the base of the otic capsule, is noted.

Fig. VIII (a and b). Embryo 7. 7 days before hatching. The neurocranium has advanced noticeably. Just in front of the hypophysial fenestra, the trabeculae are closing together. The prootic process is more prominent and another process is growing out from the anterior basicranial commissure to meet it, the postpalatine process. The otic capsule is more dense and the cartilage is beginning to grow up the sides. There is as yet no roof, although a roll of cartilage has grown up the dorsal border at each side. The semicircular canals appear within the otic capsule. The notch in the hyomandibular has closed over forming a foramen for the facial nerve.

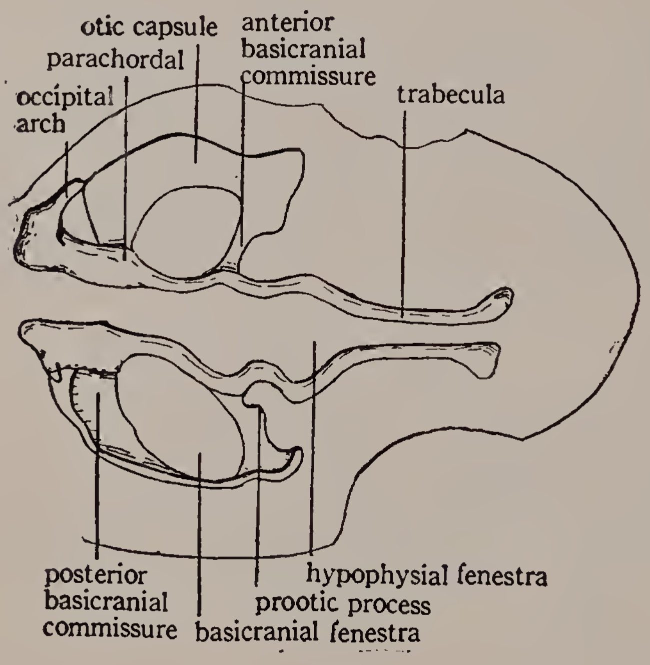


Fig. VII (a). Embryo 6, dorsal view (14 days before hatching).

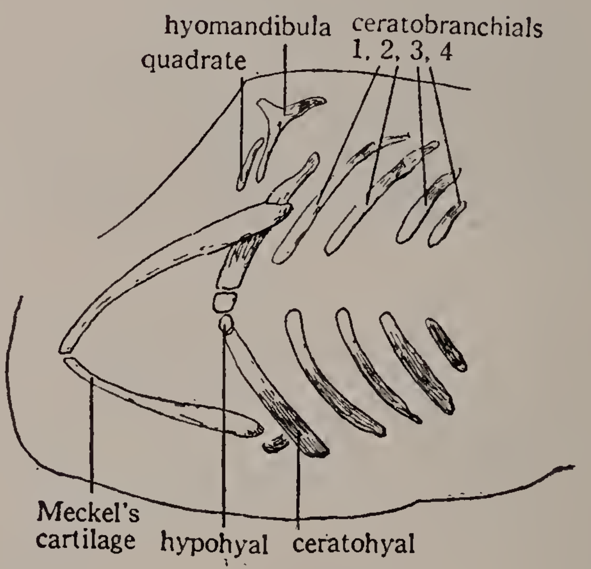


Fig. VII (b). Embryo 6, ventral view (14 days before hatching).

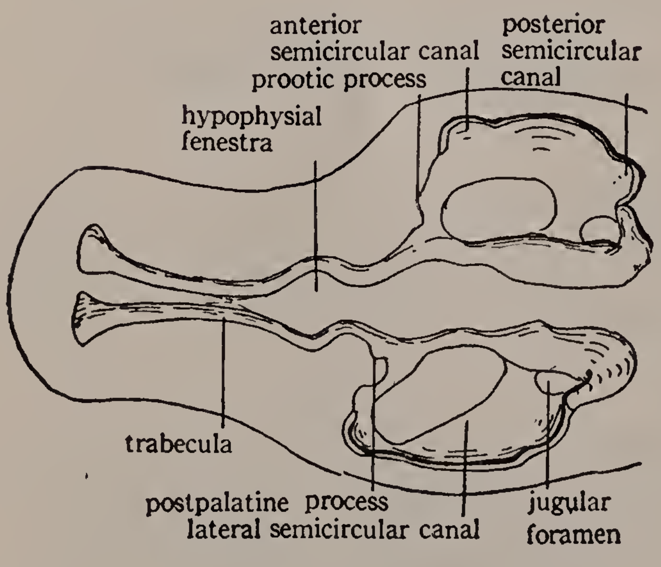

anterior semicircular canal
posterior semicircular canal
prootic process
hypophysial fenestra
trabecula
postpalatine process
lateral semicircular canal
jugular foramen

Fig. VIII (a). Embryo 7, dorsal view (7 days before hatching).

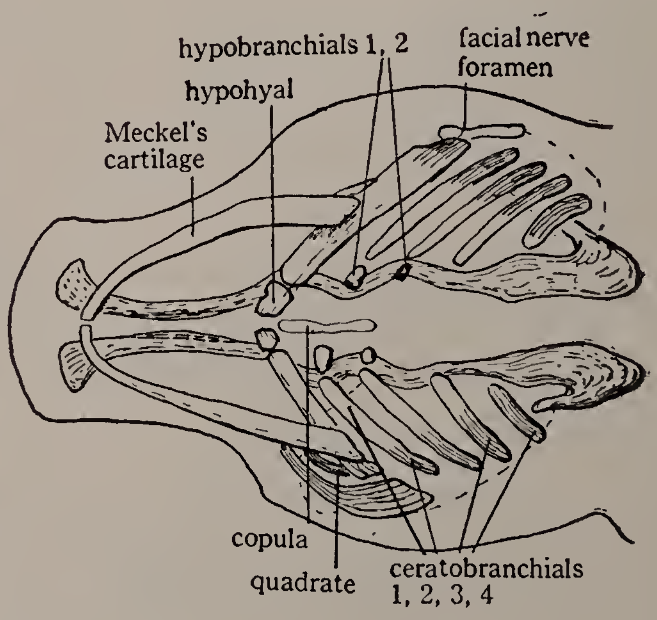


Fig. VIII (b). Embryo 7, ventral view (7 days before hatching).

Fig. IX. Embryo 8. Time of hatching. (*Hatching extends over three weeks. This embryo was taken at the mid-period*). The trabeculae have joined at the anterior ends to form the ethmoid plate and a narrow bridge has formed between them in front of the hypophysial fenestra, the trabecula communis. The developing otic capsule may be seen by the figure to have extended about half way up each side with two thin bars extending above to form the beginning of the roof. Several new cartilages have been added to the visceral arches. The stylohyal appears between the junction of the hyomandibula and symplectic and the posterior end of the ceratohyal. The basihyal is an unpaired median cartilage in front of the hypohyals. The copula extends in the mid-line to the level of the third branchial arch and the hypohyals of the first three branchial arches have arisen between the copula and the ceratobranchials.

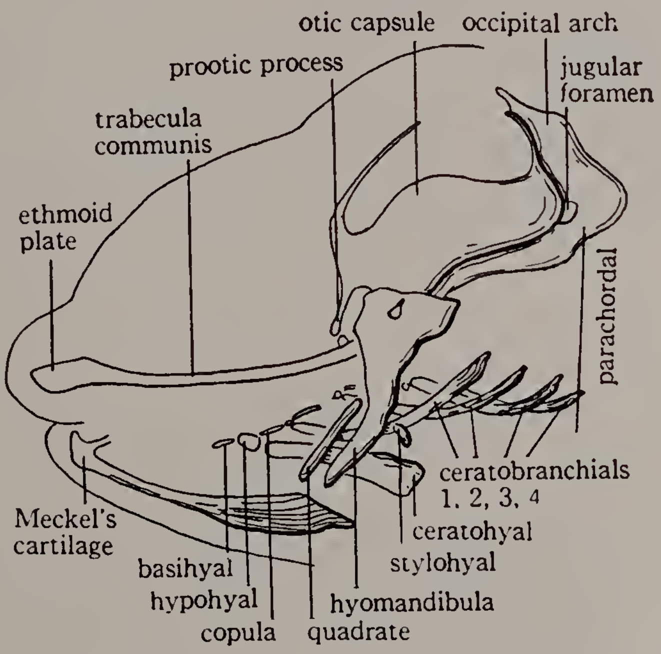


Fig. IX. Embryo 8, lateral view (time of hatching).

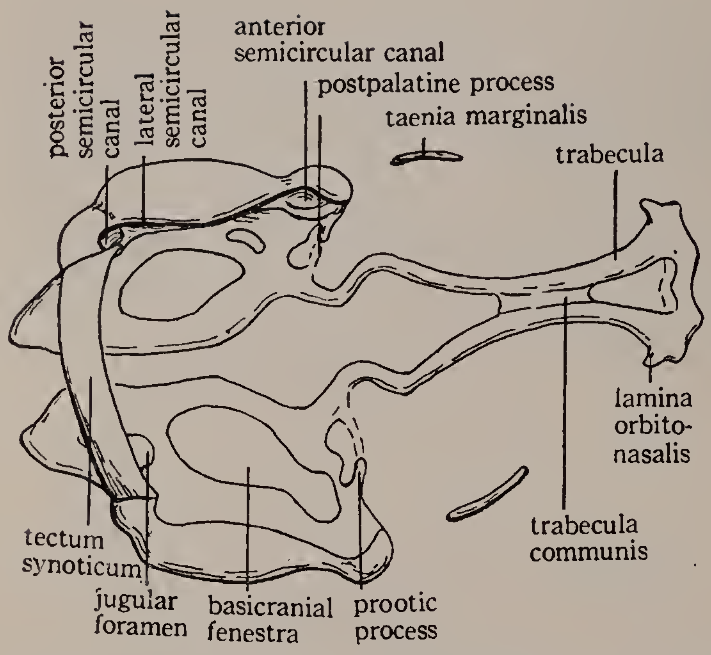


Fig. X (a). Embryo 9, dorsal view (7 days after hatching)

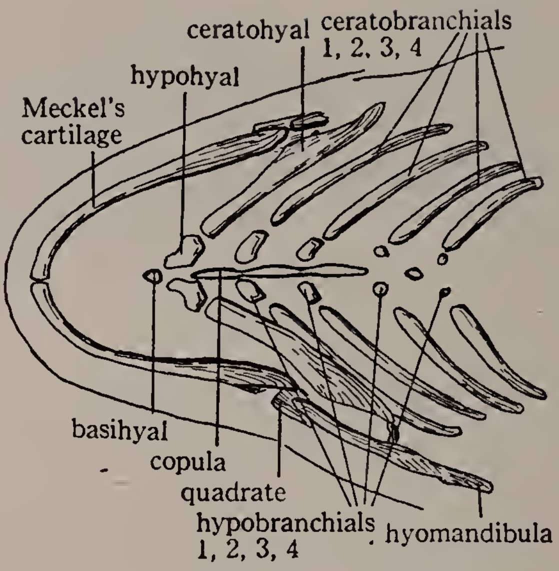


Fig. X (b). Embryo 9, ventral view (7 days after hatching)

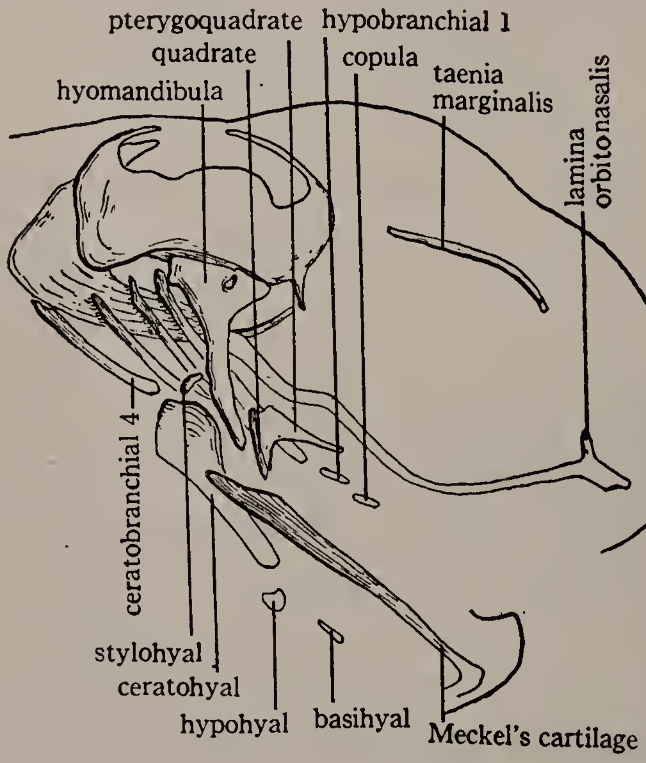


Fig. X (c). Embryo 9, lateral view (7 days after hatching).

Fig. X (a, b and c). Embryo 9. 7 days after hatching. Two important structures appear in this stage; the taenia marginalis and the pterygoid process of the quadrate. The taenia marginalis arises anterior to and slightly below the dorsal edge of the otic capsule. The cartilage will grow backward and join the otic capsule and forward to fuse with the ethmoid plate. The roof of the otic capsule has begun, and a narrow bridge of cartilage joins the occipital arches dorsally, completing the foramen magnum. The bridge represents a part of the tectum synoticum which will form the roof of the posterior parts of the brain. The semicircular canals are plainly visible through the otic capsule. The otic capsule and occipital arch have joined dorsally closing the jugular foramen. The trabecula communis has extended farther forward between the trabeculae toward the ethmoid plate. Upgrowths are developing on the posterior lateral borders of the ethmoid plate, the laminae orbitonasales. They will fuse with lateral downgrowths from the taeniae marginales. The pterygoid process of the quadrate, the future upper jaw, also makes its appearance at this time. It extends only a short distance forward as yet. The copula has reached the level of the fourth ceratobranchial and the hypobranchial of the fourth branchial arch has arisen.

Fig. XI. Embryo 10. 14 days after hatching. The specimen is considerably larger than the previous one. The taeniae marginales have lengthened at both ends; posteriorly they approach the otic capsules and anteriorly both are produced into two processes, one lateral, the other median. The lateral process grows down to meet the lamina orbitonasalis; the median process will eventually fuse with an unpaired median upgrowth from the anterior border of the ethmoid plate, the interorbital septum. In the region of the otic capsule, the prootic process and the postpalatine process have joined. The connection is called the lateral commissure and forms a foramen for the exit of the jugular vein and the hyomandibular nerve. The sides of the otic capsule are almost complete and through the walls the anterior, lateral, and posterior

semicircular canals are visible. The pterygoquadrate has extended farther forward. The ceratobranchial of the fifth branchial arch appears as a short rod.

Fig. XII (a, b and c). Embryo 11. 21 days after hatching. The taeniae marginales have joined the otic capsules posteriorly; anteriorly, the lateral processes have fused with the laminae orbitonasales. A thickening appears on the inner side of the middle of each taenia marginalis. These will grow together to form the epiphysial bar. The trabecula communis has fused with the ethmoid plate. Under the ethmoid plate an anterior centre of chondrification arises from the pterygoquadrate which is joined to the rest of the pterygoid process by a thin thread of cartilage. The anterior end of the pterygoid exhibits an ethmopalatine and a rostropalatine articulation.

Fig. XIII. Embryo 12. 28 days after hatching. The epiphysial bar has formed between the taeniae marginales and is thickening to form the tectum, the roof of the anterior part of the skull. The interorbital septum has fused with the median processes of the taeniae marginales. The sides of the otic capsules are now complete. The pterygoquadrate reaches well forward to the level of the ethmoid plate. The epibranchials of the first and second branchial arches have appeared between the parachordals and the posterior ends of the ceratobranchials.

Fig. XIV (a, b and c). Embryo 13. 35 days after hatching. The otic capsule is partially roofed with cartilage and the tectum synoticum is wider. The basicranial and jugular foramina are smaller and the foramen enclosed by the lateral commissure is becoming secondarily divided into two. The visceral arches have grown more substantial. Five ceratobranchials, four hypobranchials, three epibranchials and only one pharyngobranchial are present. The copula extends down the middle in two segments; one for the first three branchial arches, and one for the last two. The side view of this specimen shows clearly the relation of the cartilages.

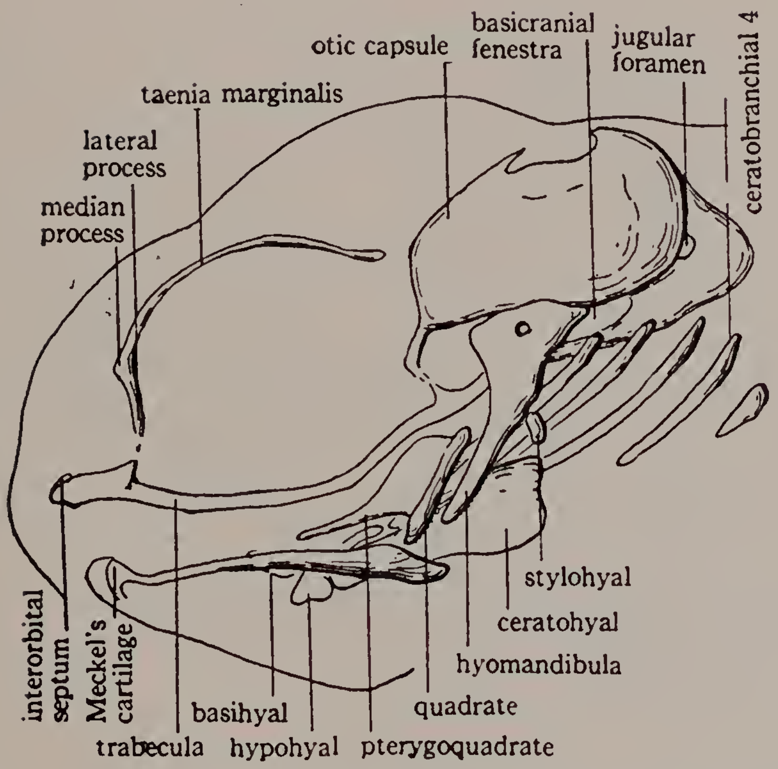


Fig. XI. Embryo 10, lateral view (14 days after hatching).

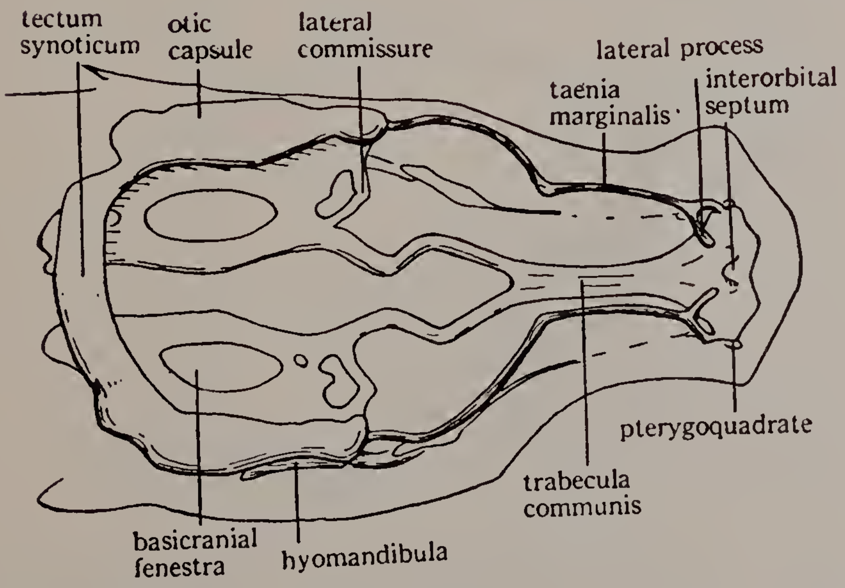


Fig. XII (a). Embryo 11, dorsal view (21 days after hatching).

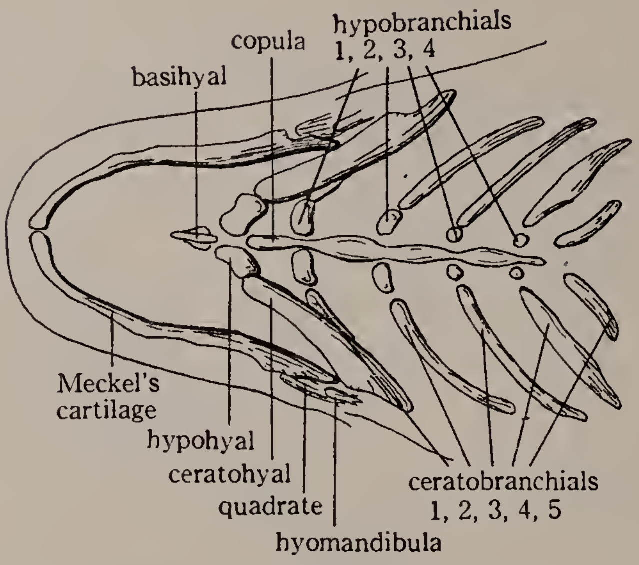


Fig. XII (b). Embryo 11, ventral view (21 days after hatching).

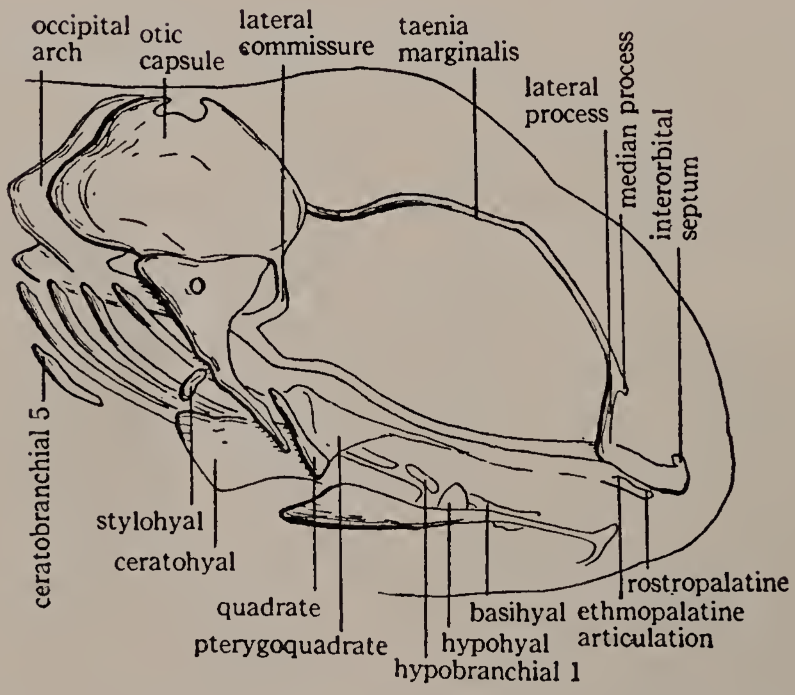


Fig. XII (c). Embryo 11, lateral view (21 days after hatching.)

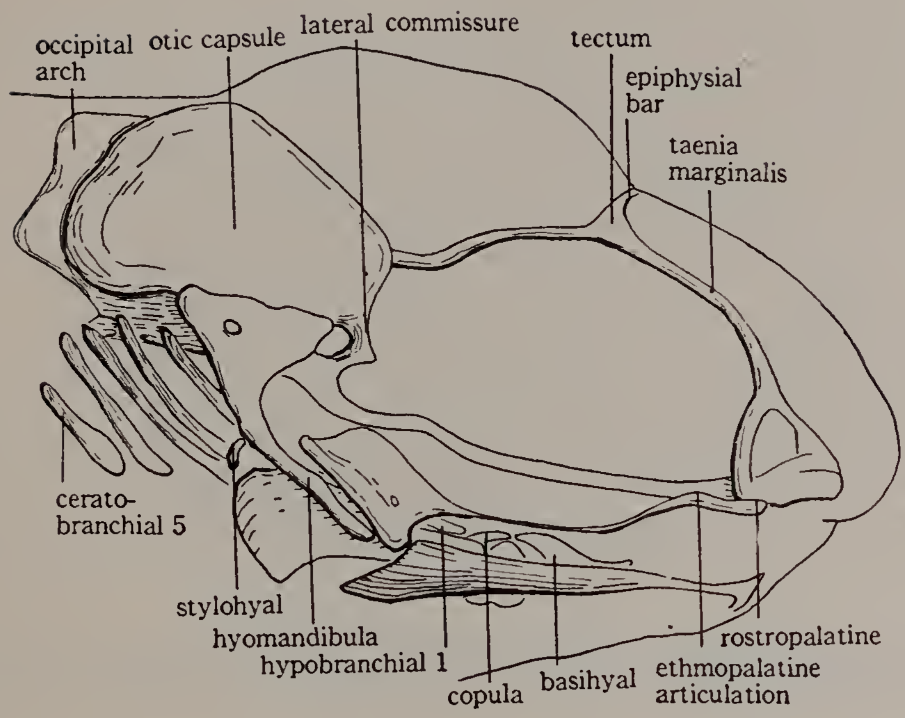


Fig. XIII. Embryo 12, lateral view (28 days after hatching).

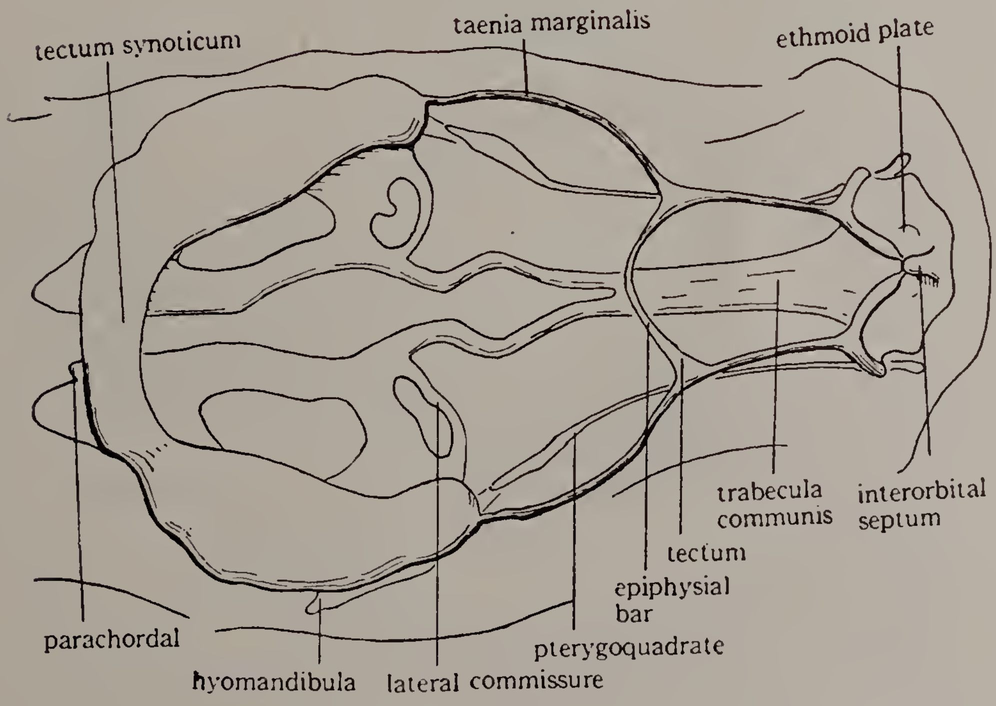


Fig. XIV (a). Embryo 13, dorsal view (35 days after hatching).

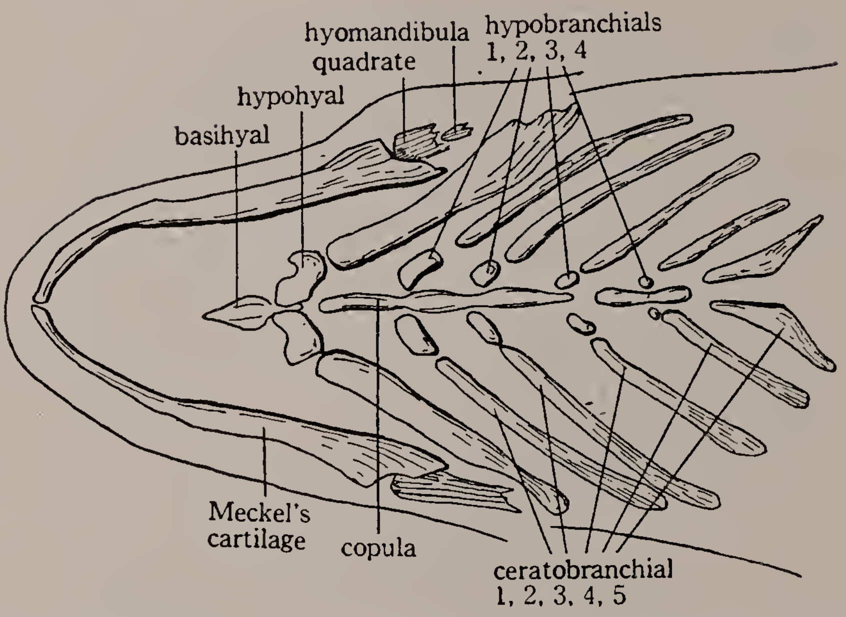


Fig. XIV (b). Embryo 13, ventral view (35 days after hatching).

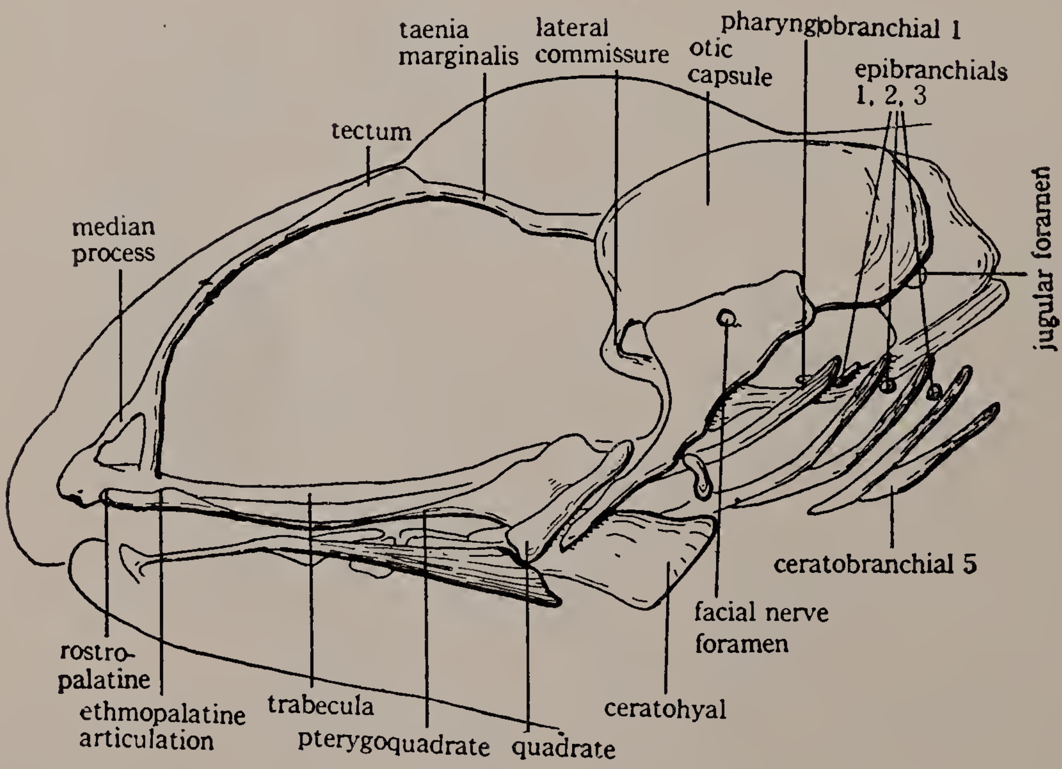


Fig. XIV (c). Embryo 13, lateral view (35 days after hatching).

Fig. XV. Embryo 14. 41 days after hatching. The whole head of this specimen has become elongated and flattened, a characteristic which persists in older embryos. It also presents several developments among the foramina. A list provided by Gaupp[3] of the nerves and vessels which exist from the various foramina has been incorporated into figure XV. The foramina and nerves are:—

1. The jugular foramen, between the occipital arch and the otic capsule which provides an exit for the vagus nerve.
2. The foramen enclosed by the lateral commissure and the anterior basicranial fenestra which is completely divided into two. The jugular vein emerges through the antero-lateral foramen; the hyomandibular nerve of VII through the median one.
3. The basicranial fenestra which is situated in the floor of the otic capsule. Through it the glossopharyngeal nerve emerges.
4. A foramen in the hyomandibula providing an exit for the facial nerve.

Gaupp's figure which shows the foramen enclosed by the lateral commissure, completely divided into two at this stage, has been confirmed. De Beer[5] finds only a single foramen in the trout. A diagram (figure XX) has been made using Gaupp's model. The cartilages are more developed than any stage described here and the foramina for nerves and vessels show clearly. Two foramina were found in the hyomandibula of two specimens out of five examined at this stage. A possible explanation is that the facial nerve divides into two before leaving the skull. The pharyngobranchials of the second and third branchial arches have appeared.

Fig. XVI (a, b and c). Embryo 15. 48 days after hatching. The neurocranium is more solid. The taeniae marginales and the tectum synoticum have enlarged. The ethmoid region is well developed. In the side view (a) the mouth is wide open showing very clearly the relations of the visceral arches.

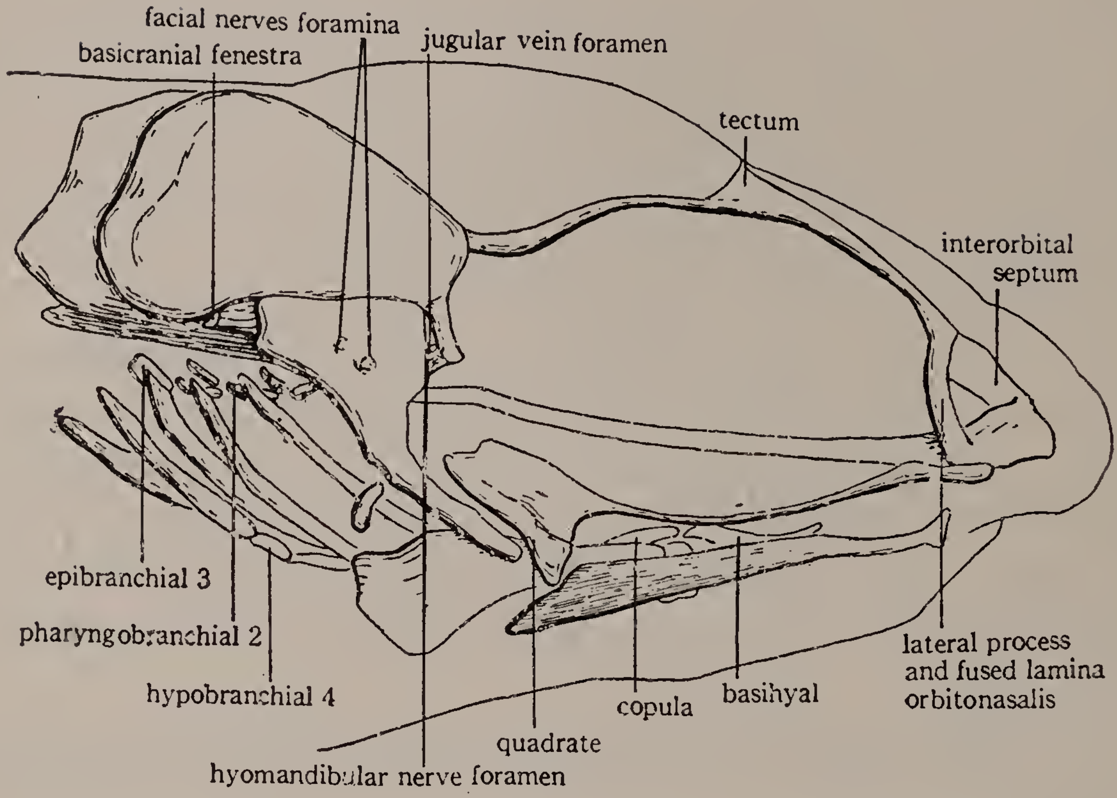


Fig. XV. Embryo 14, lateral view (42 days after hatching).

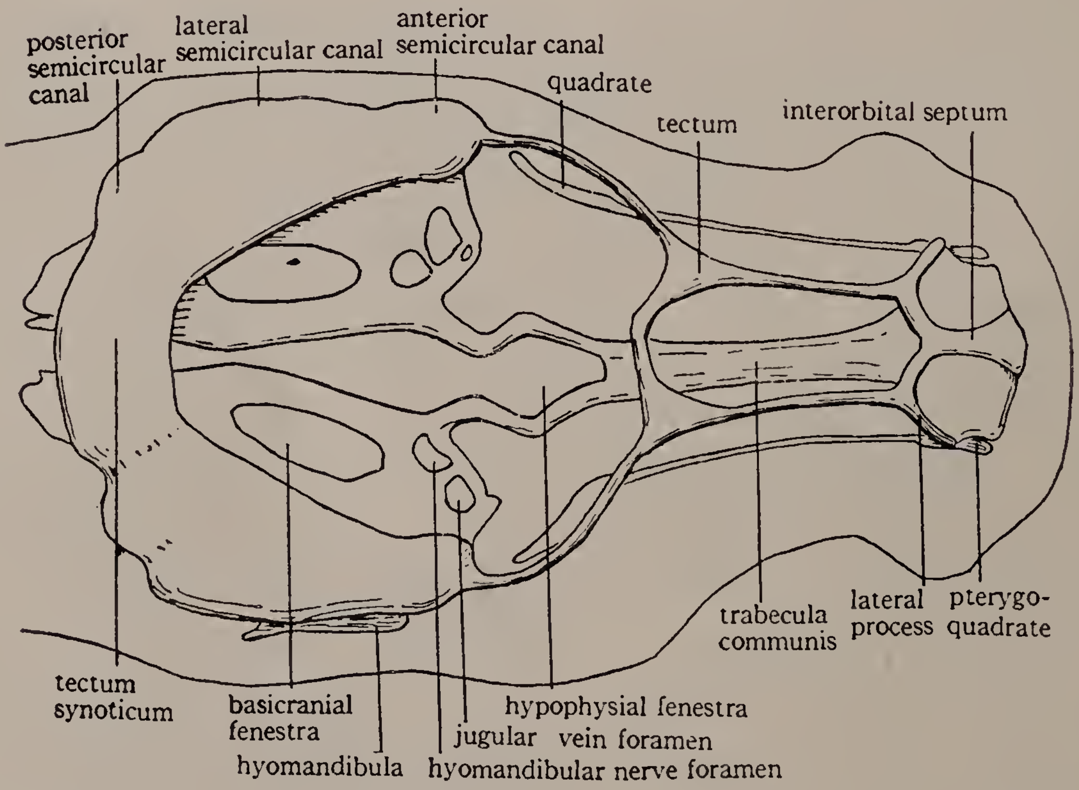


Fig. XVI (a). Embryo 15, dorsal view (48 days after hatching).

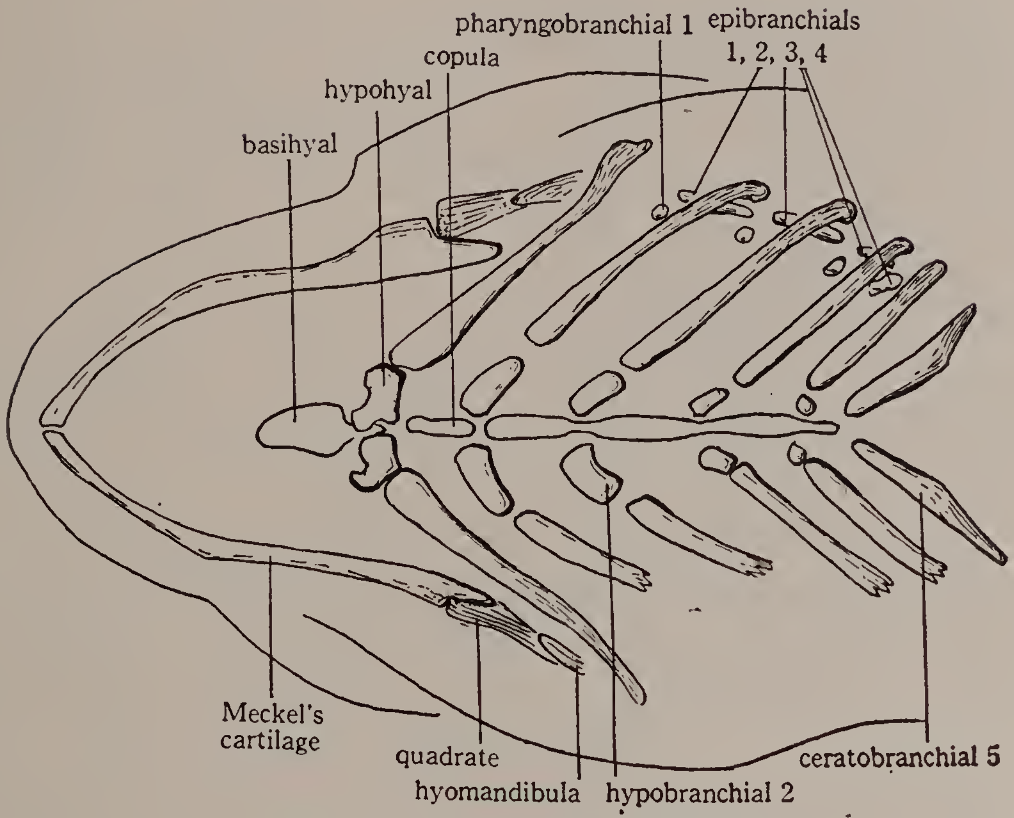


Fig. XVI (b). Embryo 15, ventral view (48 days after hatching).

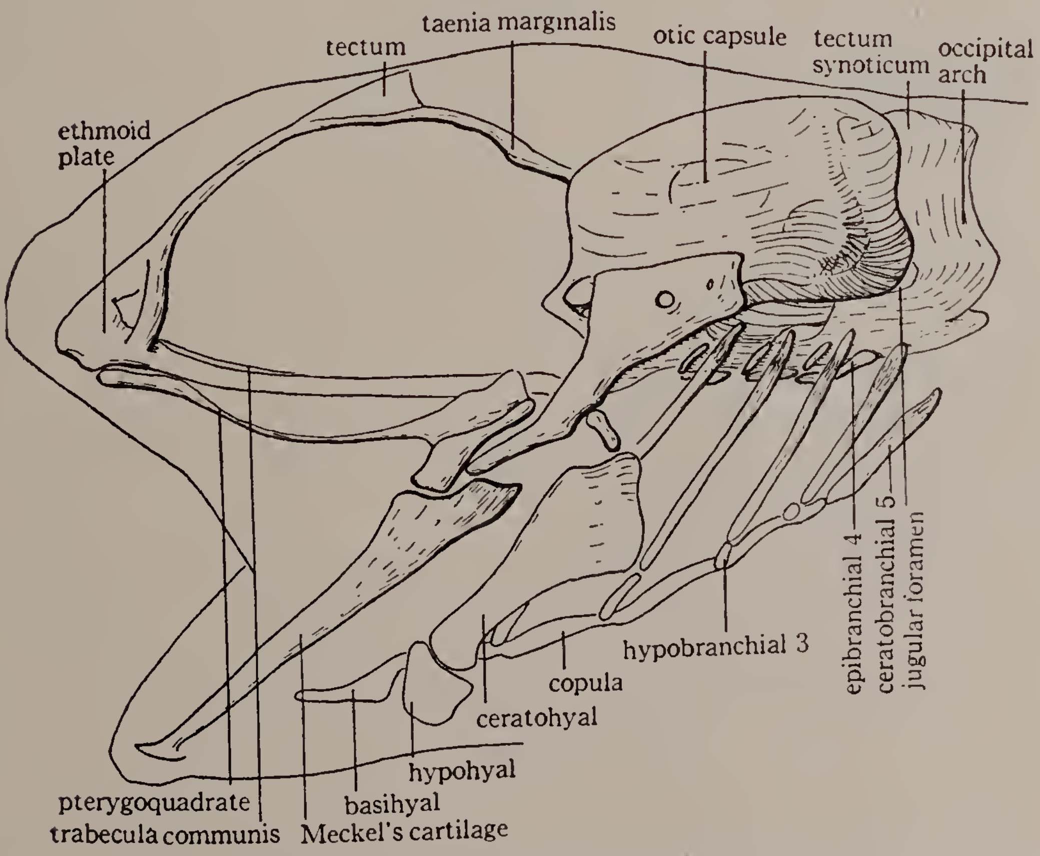


Fig. XVI (c). Embryo 15, lateral view (48 days after hatching).

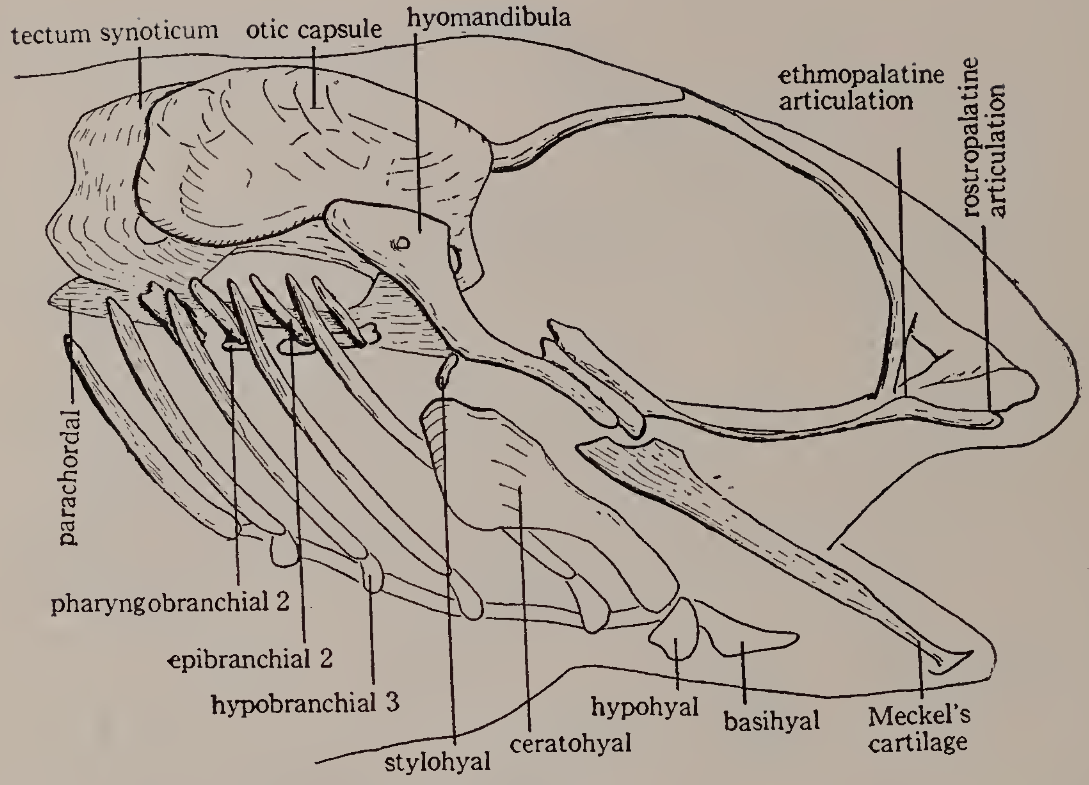


Fig. XVII. Embryo 16, lateral view (55 days after hatching).

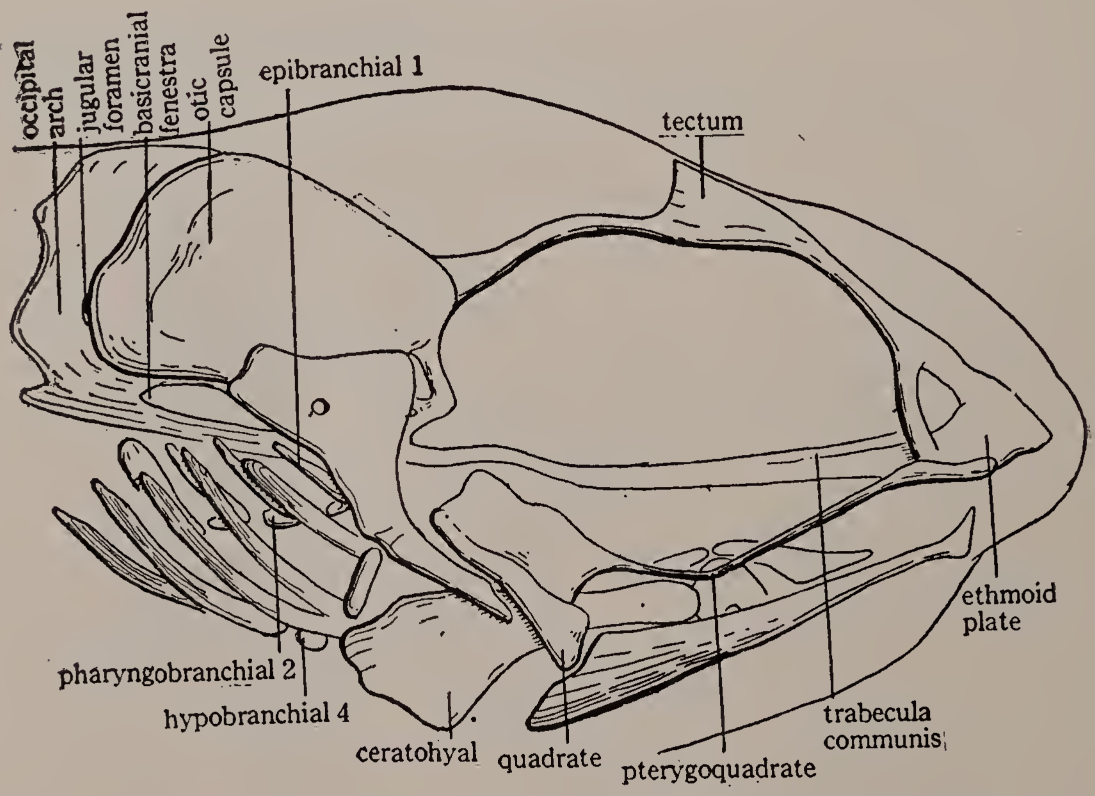


Fig. XVIII. Embryo 17, lateral view (62 days after hatching).

Fig. XVII. Embryo 16. 55 days after hatching. This embryo has been drawn on an angle from the ventral side resulting in a distortion which makes the pterygoquadrate appear to be slightly above the trabecula. The visceral arches are clear and the fourth epibranchial and third pharyngobranchial are present. The nasal capsule is becoming closed over with cartilage from the anterior edge of the ethmoid plate. The ethmopalatine and the rostropalatine articulations are very well marked on the anterior extremity of the pterygoid process.

Fig. XVIII. Embryo 17. 2 days after hatching. This specimen shows the tectum closing over between the eyes. The cartilage is still thinner in the region where the hyomandibula and symplectic have fused. The pharyngobranchials and epibranchials are larger.

Fig. XIX. Embryo 18. 9 days after hatching. This was the final stage studied. No new structures appear but those already there have enlarged. It will be noted that there are two foramina in the hyomandibula of this specimen also. The visceral structures are clear.

THE RATE OF CARTILAGE FORMATION.

It is obvious that yolk cannot be visibly turned into cartilage, or anything else, in an embryo without an accompanying chemical alteration, capable of detection by suitable tests. Very little is known about the origin of cartilage even in adult mammals and Miyazoki[6] is only now perfecting a technique for this sort of investigation. If it were possible to furnish from the morphological side figures showing the rate of cartilage formation in an embryo at various stages and to set them up against chemical analyses of corresponding material, an attack on the cartilage problem from a new angle could be made. Complete chemical analyses of salmon embryos are lacking, but from the material in this paper the necessary morphological data may be compiled.

[6] Miyazoki. *Journ. Biochem*, **20**, 211, (1934).

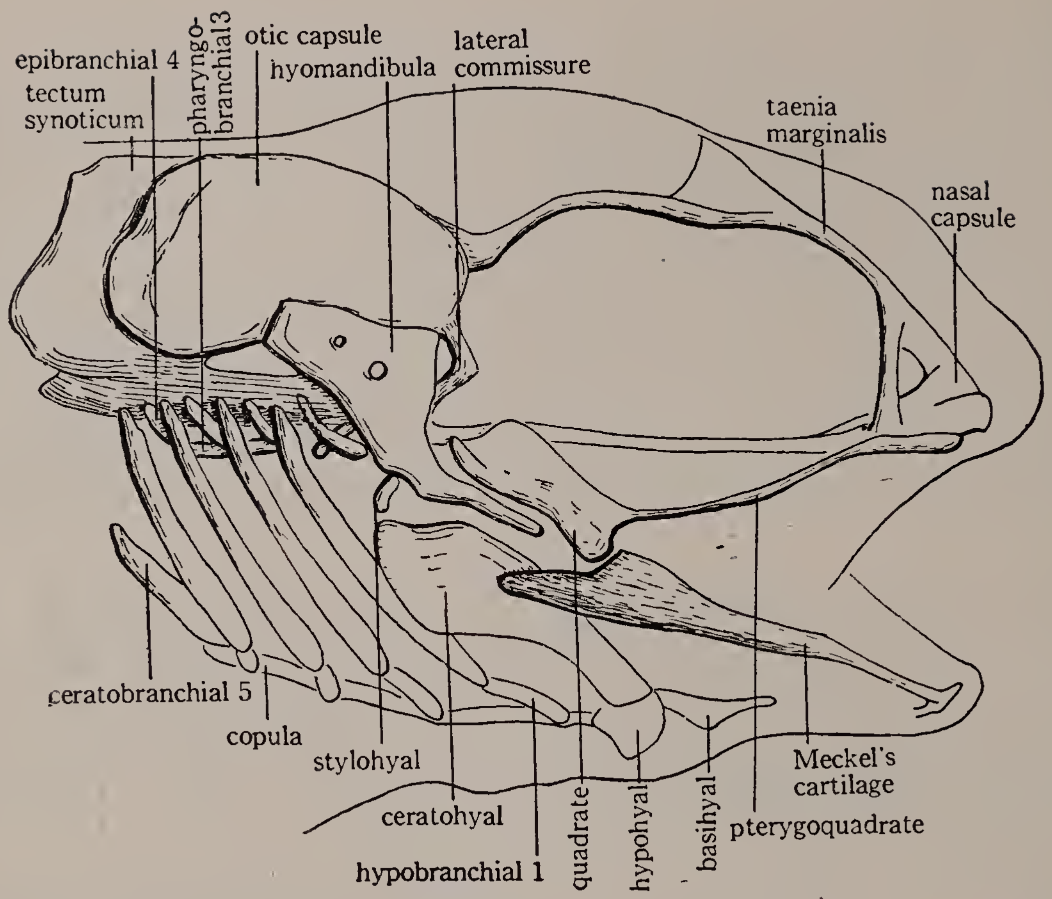


Fig. XIX. Embryo 18, lateral view (69 days after hatching).

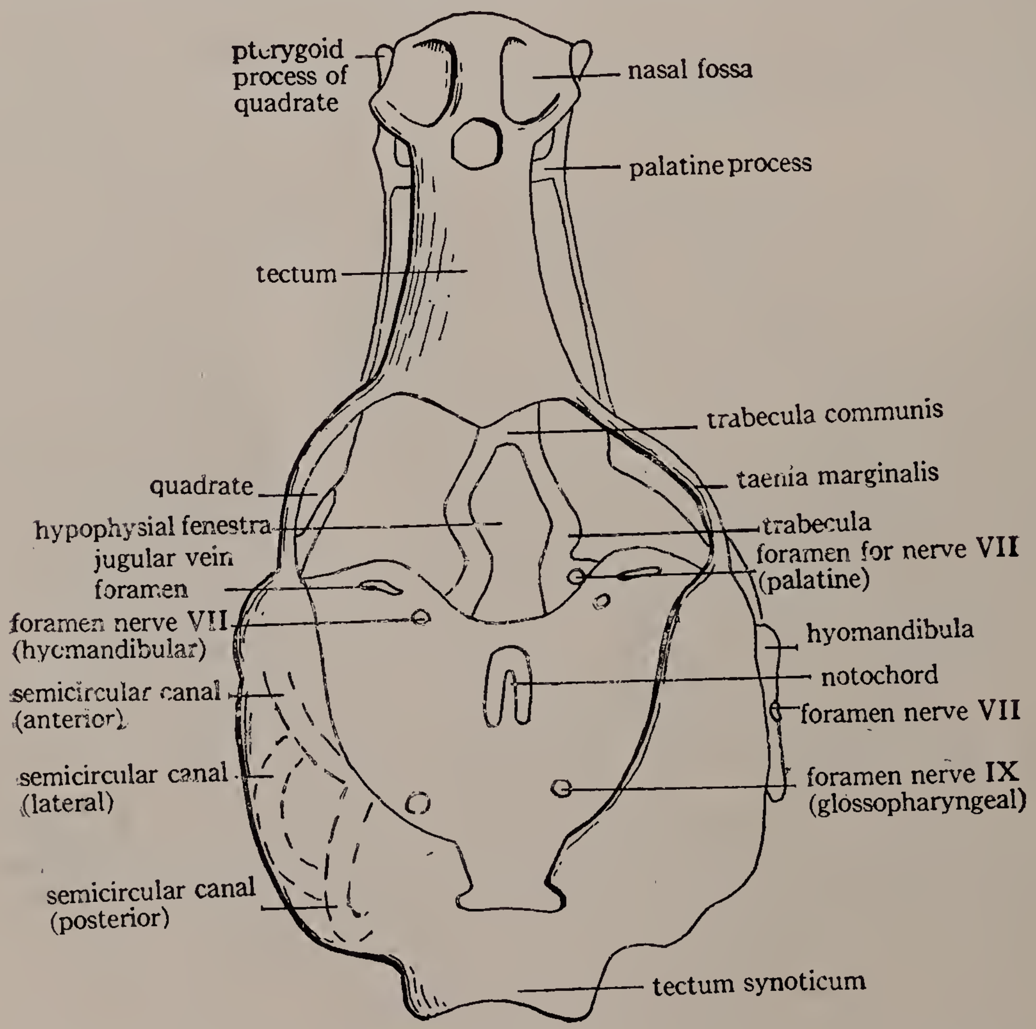

pterygoid process of quadrate
nasal fossa
palatine process
tectum
trabecula communis
quadrate
taenia marginalis
hypophysial fenestra
trabecula
jugular vein foramen
foramen for nerve VII (palatine)
foramen nerve VII (hyomandibular)
hyomandibula
notochord
semicircular canal (anterior)
foramen nerve VII
semicircular canal (lateral)
foramen nerve IX (glossopharyngeal)
semicircular canal (posterior)
tectum synoticum

Fig. XX. Diagram to show exit of nerves and blood vessels (After Gaupp).

Three quantitative uses have been made of the drawings. No one of them is entirely free from objection: taken together however, they permit, by their agreement with one another, conclusions and suggestions.

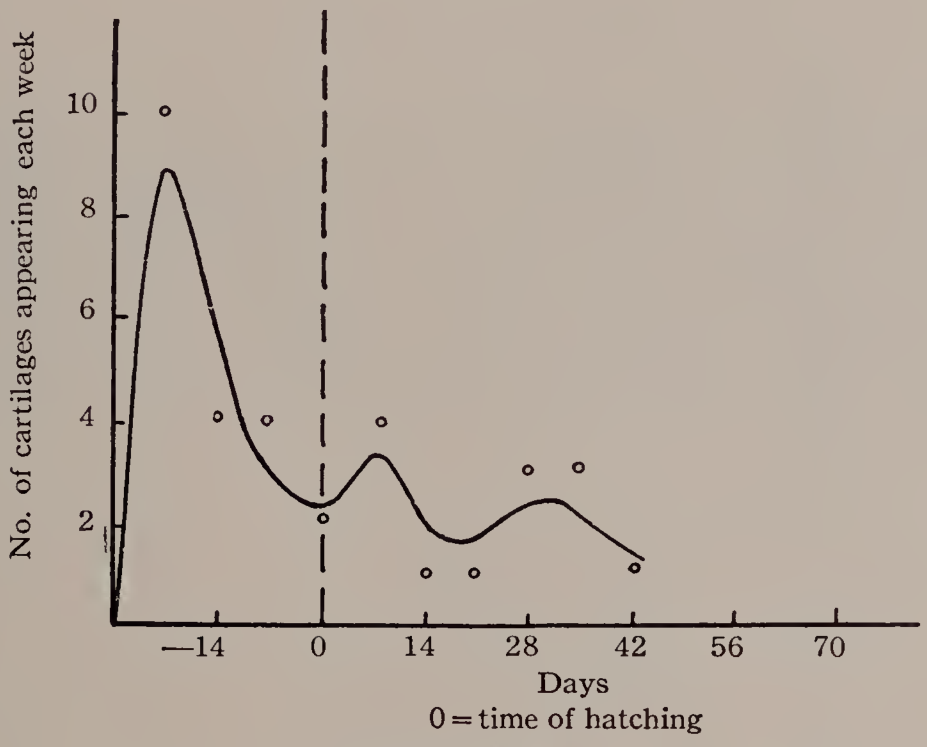


Fig. XXI.

Figure XXI shows a curve made by plotting the number of new cartilages appearing each day against time. This curve shows a sharp rise during the fourth week before hatching when cartilage first originates. The number of new cartilages appearing each week falls off until hatching. A sudden rise occurs the week after hatching followed by a drop, after which the number increases again. The maximum number of cartilages, 33, is reached 6 weeks after hatching. The curve illustrates three points: first, that there is an irregularity at hatching; second, that the effects of hatching are felt for three subsequent weeks; third, that there is a subsequent resumption of the interrupted embryological processes. The sudden rise after hatching may be due to the release of the perivitelline fluid and hatching enzymes which have been retarding development previous to hatching.

The principal sources of error are that considerable differences exist in the sizes of cartilage pieces even on their first appearance, and that no account is taken of growth subsequent to initial appearance. The first of these difficulties is made less serious by the large number of cartilages involved, 33 in all.

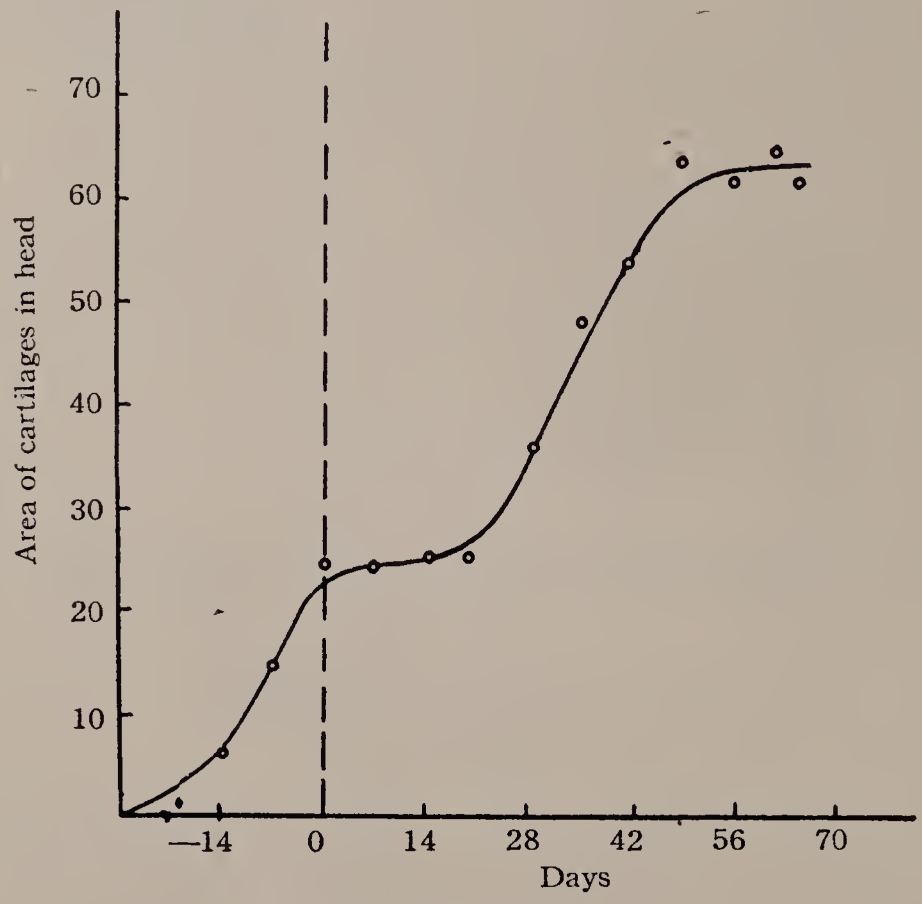


Fig. XXII

Figure XXII has been made by plotting against time the total area of cartilage seen on one side of the head. On drawings of the lateral views of various embryos, the area in square centimeters of each cartilage was measured with the aid of a planimeter, and the total added up. The curve shows several interesting points. It will be noted that there is a rapid development of cartilage from the origin, three weeks before hatching, up to the time of hatching. At the time of hatching development ceases abruptly and the curve flattens out almost to a straight line for three weeks, after which it rises again rapidly until it reaches a maximum about sixty days after hatching, where it remains. The results supplement and confirm figure XXI and are not subject to its errors of method. They fail, however, to show the relationship of cartilage area to total head, obviously a point of importance.

This latter defect has been eliminated in the curve of figure XXIII, which shows the ratio

$$\frac{\text{total cartilage area}}{\text{head area}}$$

plotted against time. It shows a rise up to the time of hatching a, sudden drop and then a rise again. The explanation for the drop after hatching, since the cartilage area is known from figure XXII to be a constant at this time, is that the head continues to increase in size for about 2 weeks after the time of hatching when its growth stops for a short time.

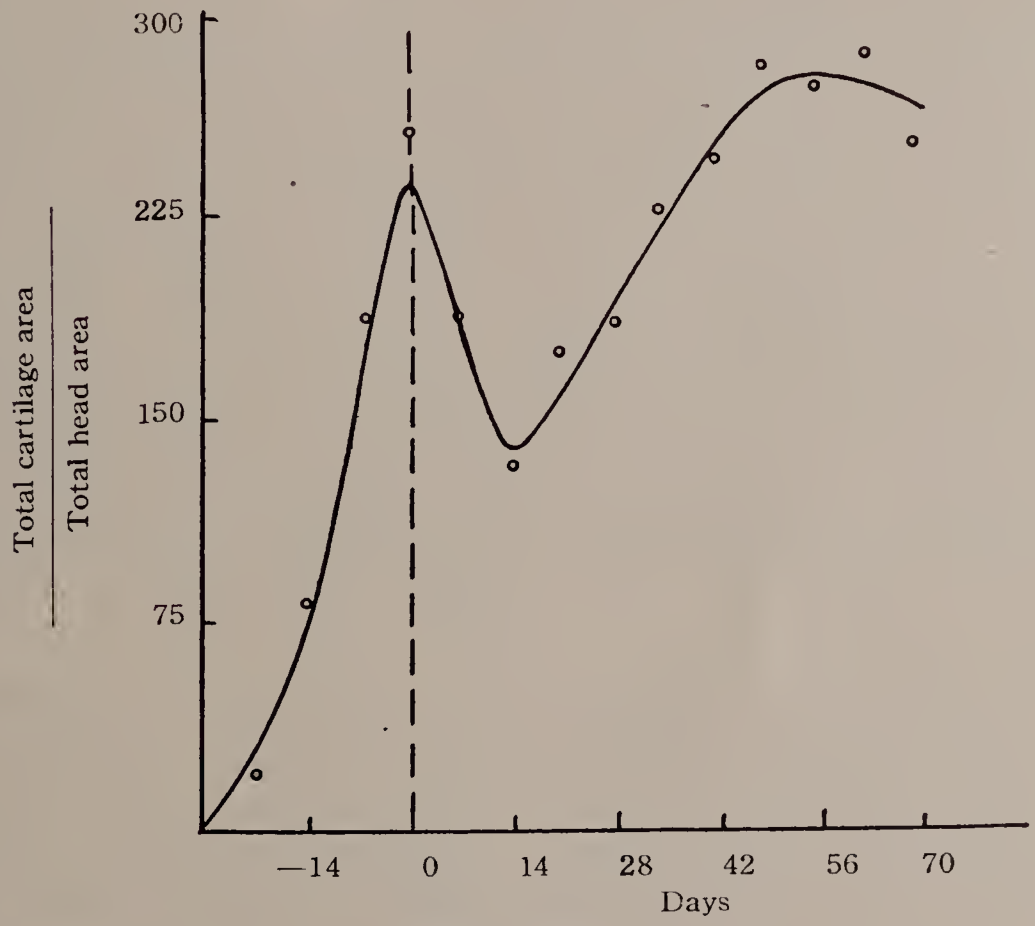


Fig. XXIII.

The reason for presenting figures XXII and XXIII in terms of area rather than volume is that the volume of an area curving over the top of an embryonic head cannot be accurately estimated either from a drawing or from the animal itself. The fact that all the cartilages of the head are about the same thickness minimizes the error inherent in the method as used. The total area of the head was measured from a lateral view in the same way as the cartilage areas, the back of the head being considered as a perpendicular line drawn at the posterior end of the parachordal.

There are several possible explanations for the slackening off of cartilage development at hatching. A great many essential changes are taking place at this critical period in the life of the salmon. Most of the available energy of the embryo is turned to the effort of hatching to produce, for instance, the characteristic shell digesting enzymes. This could well result in a pause in the building of new structures. The act of hatching demands a great deal of movement on the part of the embryo which uses much energy. This movement and its utilization of energy continues in the free swimming larva. A new process is brought into being by the act of hatching, respiration by means of gills, another demand to cut down the amount of energy available for building new tissues. All of these features together at the time of hatching could cause the arrest in cartilage formation. Furthermore, it was found that not only did the cartilages already present stop growing, but also that few new ones made their appearance during this critical period. After three weeks, the embryo has recovered from the effects of hatching and has readjusted itself to the new mode of respiration; then cartilage development proceeds again.

The chemical explanation for this behaviour of cartilage will be interesting. Cartilage is known to be a mucoprotein, chondroitin sulphuric acid, but little else is known about its composition or how it is formed. Steudel and Osato[7] analyzed the shell of the herring egg and found no mucoprotein in the shell. They suggest that mucoprotein may be found in the jelly surrounding the shell. While the shell has never been seriously considered as a source of embryonic building material, the possibility should not be overlooked. Hayes[8], working on the chemical changes in the salmon embryo, has found the curve for fat to correspond closely to that shown in figure XXIII. It may be that when more is known about the chemistry of mucoprotein these facts may be correlated.

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[7] Steudel & Osato. *Hoppe-Seyler's Zeitschrift fur physiologische Chemie*, **127**, 220, (1923).

I am very grateful to Dr. F. R. Hayes, under whose direction this research has been carried on, and to Dr. D. Pelluet for her assistance and many suggestions.

[8] Hayes. *Journ. Biochem.* **24**, 3, 735, (1930).

PRESIDENTIAL ADDRESS.

A. H. LEIM.

(Read October 10, 1934).

It is my pleasure to discharge the duties laid upon the President of the Nova Scotian Institute of Science and to report on the events of the 1933-34 Institute year. I regret that circumstances do not permit me to be present at the 73rd Annual Business meeting.

Since the last annual meeting two members of the Institute have died. The first to pass was the late Dr. John Stewart, who died on December 26th, 1933. Born in 1848 at Black River, Richmond County, N. S., he had a long and distinguished medical career. In 1894 he was a member of the teaching staff of the Halifax Medical College. He was associated with Dalhousie University for over twenty years, becoming Professor of Surgery in 1913 and serving as Dean of the Medical School from 1919 to 1931. Dr. Stewart joined the Institute in January, 1885, and at the time of his death was the senior member. In recent years he was rarely seen at the meetings of the Institute but your President recalls his attendance about three years ago on a stormy evening when a paper on a natural history subject was being read.

The other passing was that of the late Professor Donald Sutherland McIntosh who was born at Pleasant Bay, Inverness Co., N. S., in 1862, and who died on July 20th, 1934. From 1910 to 1931 he was associated with the teaching of Geology and Mineralogy at Dalhousie University. He joined the Institute in 1911 and was elected to the Council in the following year, serving on it continuously until 1932. His quiet and unassuming presence will be missed after so long an association.

During the year five ordinary members and one associate member were elected to the Society.

Seven ordinary meetings of the Institute were held during the past session and twenty-two papers were read. These papers may be classified as follows:

Bacteriology	1
Biochemistry	1
Biology	2
Botany	1
Chemistry	3
Dentistry	1
Geology	3
Hydrology	1
Meteorology	1
Physics	4
Physiology	4

The average attendance at the meetings was twenty.

The Provincial Government grant of five hundred dollars was continued.

Part 3 of Volume XVIII of the "Proceedings of the Nova Scotian Institute of Science", for the session of 1932-33, was issued during the year. It contained nine complete papers, totalling one hundred and forty pages. It is gratifying to see the increase in size in the publication, and the Editor, Dr. King, deserves the thanks of the Institute for his work in connection therewith.

The Council sanctioned an attempt to compile a catalogue of the scientific publications available in the Maritime Provinces in University and other libraries, and the Corresponding Secretary, Dr. Hess, is largely responsible for the very considerable progress made in securing lists from the various libraries. In the absence of any up-to-date catalogues of this kind the Institute would perform a very useful function by having these lists correlated and made available.

In my address of a year ago I stressed the desirability of another Science Exhibition being arranged by the Institute. It did not prove feasible to provide for such an exhibition during the year. I can only express the hope that at some future date it will be possible to again bring some of the methods and results of scientific research before the public of Halifax in this way.

I should like to take this opportunity of making a few remarks on the field of research in oceanology. I trust that it will be considered a proper part of this address under the section of the constitution which reads that a President may treat "such other topics as he may deem conducive to the welfare of the Institute and to the promotion of its objects". An important part of the resources of Nova Scotia is related to the sea, and the events that occur therein should be of importance to the exploitation of that resource. From a non-commercial and purely scientific point of view the study of the sea is filled with interest. Such studies are apt to be thought of as involving only biology, but in the broad view each one of such sciences as physics, chemistry, biochemistry, physiology and geology will find much to be done in its own field in a study of the oceans. This is not the time nor place to elaborate on what these problems are. They have been summarized in recently published treatises on the subject by experts in oceanology.

In this connection I wish to draw your attention to the fact that each of the three larger Universities in Nova Scotia is located almost within a stone's throw of the sea. One is on the open Atlantic coast; one on the Bay of Fundy and one on the Gulf of St. Lawrence. These waters are strikingly different and these Universities possess unrivalled opportunities for marine research by virtue of their geographical position.

I would therefore commend to the Institute that it continue to welcome papers on marine research and provide an avenue of publication for them and to its University members that they give some thought to this aspect of research, since it is only when an active interest in these problems is awakened in the minds of the investigators that real progress is made.

In conclusion I wish to thank the members of the Institute again for the honour of its Presidency for two years, and to thank the members and particularly the members of the Council for their assistance.

PROCEEDINGS OF MEETINGS.

SESSION OF 1934-35.

(All meetings were held in the Medical Science Building, Halifax).

73rd Annual Business Meeting, Oct. 10, 1934. In the absence of the President, Dr. A. H. Leim, his address was read by the Recording Secretary.

The Treasurer's report showed the financial situation to be as follows: Receipts during the year, $1,580.32; expenditures, $954.47; balance in hand (current account), $625.85; reserve fund, $738.03; permanent endowment fund, $2,500.00.

The Corresponding Secretary reported that 216 back copies of the Proceedings had been sent out.

Steady progress in the Institute's library was revealed by the Librarian's report, which showed: books and pamphlets in the Provincial Science Library, 92,920; books and pamphlets received through exchange and purchase during the year, 3,861; books and pamphlets borrowed during the year, 1,001; volumes bound during the year, 92.

Officers elected for 1934-35: *President,* Harry Piers, Esq; *vice-presidents,* Prof. George H. Henderson, Ph.D., Prof. Harold S. King, Ph.D.; *treasurer,* Donald J. Matheson, B.Sc.; *corresponding secretary,* Prof. Ernest Hess, Ph.D.; *recording secretary,* Prof. F. Ronald Hayes, Ph.D.; *librarian,* Harry Piers; *members of the council,* Capt. W. F. Mitchell, Rev. Bro. Cornelia, Prof. C. C. Coffin, Ph.D., Prof. R. J. Bean, Margaret R. Butler, Ph.D., Prof. S. A. Beatty, Ph.D., Prof. G. V. Douglas.

1st Ordinary Meeting, Nov. 12, 1934. New members announced (elected by Council Nov. 5): Ordinary members, D. B. Finn, E. P. Linton, V. D. Vladykov, R. A. McKenzie; Student members, W. R. Inman, D. M. Ross, Helen R. Belyea.

Obituary:—Professor Daniel Alexander Murray, Ph.D., scholar of international repute and author of many mathematical treatises, died Oct. 19, 1934. After graduating with honours from Dalhousie in 1884, he studied at Johns Hopkins Berlin and Paris. He came to Dalhousie as professor of mathematics in 1908, having previously held a similar post at New York University. Five years later he was called to McGill as professor of mathematics; at the time of his retirement in 1930 he was chairman of the department. Joining the Institute Dec. 18, 1903 (auditor for the two years 1905-7) he retained his membership until his death.

Papers: 1—Some Unreported and Rare Fishes for the Coast of Nova Scotia, by V. D. Vladykov. 2—Some Properties of the Polysaccharide Complex Extracted from a Marine Alga, *Chondrus crispus*, by M. R. Butler. 3—Further Studies on Explosive Antimony, by C. C. Coffin.

2nd Ordinary Meeting, Dec. 10, 1934. New student member announced (elected by Council Nov. 26), A. J. C. Wilson. Papers: 1—Note on a May-fly from the Halifax Region, by G. H. Henderson. 2—Cod and Water Temperature, by R. A. McKenzie.

3rd Ordinary Meeting, Jan. 14, 1935. New members announced (elected by Council Jan. 7). Ordinary member, Herbert Baxendale. Student members, R. W. Begg, W. E. Parker. Capt. W. F. Mitchell, having duly given notice of motion in the manner provided, proposed to amend the Constitution by reducing the annual fee for student members from one dollar to fifty cents. Passed unanimously. Papers: 1—Hot Wire Anemometry, by D. LeB. Cooper and E. P. Linton. 2—The "Imidazoles" of Fish Muscle, by W. W. Johnston. 3—The Goldenville-Halifax Boundary at Fairview, N. S., by Elizabeth King.

Special Meeting, Feb. 11, 1935. Mr. T. E. Kloss of the Mersey Paper Company, Liverpool, N. S., delivered a popular lecture on "The Chemistry of Paper Making".

4th Ordinary Meeting, Mar. 11, 1935. New associate members announced (elected by Council Feb. 28), H. B. Hachey, M. W. Smith. Papers: 1—The Pre-treatment of Fresh Fillets for Smoking, by D. LeB. Cooper and E. P. Linton. 2—Some New Types of Pleochroic Haloes, by F. W. Sparks. Demonstration: 3—Chemiluminescence, by J. R. Dacey.

Special Meeting, Apr. 8, 1935. New student member announced (elected by Council Mar. 25), Elisabeth C. Saunderson. Capt. W. F. Mitchell delivered a popular illustrated lecture on "Life Saving Methods Used on Board Merchant Ships, Past and Present". Shorter Papers: 1—The Life and Scientific Accomplishments of Simon Newcomb, by G. H. Henderson. 2—The Historical Development and Programme of the Nova Scotian Institute of Science, by R. J. Bean.

Fifth Ordinary Meeting, May 3, 1935. Papers: 1—The Early Development of the Cartilage Skull of *Salmo salar*, by E. C. Saunderson. 2—Notes on the Criteria for Determining the Tops of Stratified Beds, by H. R. Belyea. 3—Silicosis: its Implications and Importance, by P. Isaacson and E. D. Levittan. 4—The Halo Complex of March 4th, 1935, at St. Andrews, N. B., by H. B. Hachey. Papers read by title: 5—The Marine Fishes of Nova Scotia, by V. D. Vladykov and R. A. McKenzie. 6—Fresh-water Cladocera and Copepoda from New Brunswick and Nova Scotia, by M. W. Smith.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

SOME PROPERTIES OF THE POLYSACCHARIDE COMPLEX EXTRACTED FROM A MARINE ALGA, *Chondrus Crispus*. Margaret R. Butler, Dept. of Biology, Dalhousie Univ., Halifax, N. S. (Read Nov. 12, 1934). The material responsible for the gelatinising property of *Chondrus crispus* has been prepared in a relatively pure state, under standard conditions. The material, while largely carbohydrate in nature, leaves an ash equivalent to approximately 20% of its dry weight. The extract, previously described as an ethereal sulphate of calcium, is now shown to be a mixture of sulphates, and other substances, e. g. organic phosphates. The potassium salts of the ethereal sulphates which occur in situ have been prepared by dialysis, and found to be superior in purity to the original extract. Calcium salts were prepared by replacing the potassium in the potassium salts. Ammonium salts were also prepared. The Chondrus extract is compared with a purified sample of agar-agar to which it is frequently likened.

FURTHER STUDIES ON EXPLOSIVE ANTIMONY. C. C. Coffin, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Nov. 12, 1934). Experimental data bearing on the structure, electrical conductivity and rate of crystallization of explosive antimony are discussed.

A MAYFLY FROM THE HALIFAX REGION. G. H. Henderson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Dec. 10, 1934). Mayflies, in subimago and imago stages, were collected in the neighbourhood of Halifax, May 3 to 8, 1934. These specimens were identified by Dr. J. McDunnough, Dept. of Agric., Ottawa, as belonging to the single species, *Blasturnus nebulosus,* Walker.

COD AND WATER TEMPERATURE. R. A. McKenzie, Atlantic Biological Station, St. Andrews, N. B. (Read Dec. 10, 1934). The experimental feeding, to date, of cod kept in cement tanks supplied with running salt water has shown that, as the water gradually warms during the spring and summer, the amount of food consumed per fish increases until a certain temperature (tentatively placed between 10°C. and 15°C.) has been reached. Above this, the amount of food taken decreases rapidly as the temperature goes higher. During the season, any comparatively sudden rise in temperature has been found to bring about a decrease in the amount of food taken, while a drop in temperature causes increased feeding. The order obtaining at the extremes of the temperature range has not yet been definitely established. The small cod have a higher optimum and a wider range of feeding temperature than the large cod. While these results have not yet been fully correlated with the fishery, still they do explain the sudden cessation of fishing when the temperature rises rapidly at certain times of the year.

THE "IMIDAZOLES" OF FISH MUSCLE. W. W. Johnston, Fisheries Exp. Sta., (Atlantic), Halifax, N. S. (Read Jan. 14, 1935). The occurrence of an "imidazole" in different muscles of marine fish found off the coast of Nova Scotia is reported and some remarks are made on the properties and nature of the substance.

THE PRE-TREATMENT OF FRESH FILLETS FOR SMOKING. D. LeB. Cooper and E. P. Linton. Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read March 11, 1935). The determination of the optimum conditions for the production of a satisfactory sheen and surface by a combination of salting and drying has been carried out on single fillets in small tunnels. The results obtained in this manner have been applied to the design of tunnels of commercial length, operated under conditions approximating those used in plant practice. It has been demonstrated that fresh fillets may be prepared for smoking in a continuous manner in all classes of weather in approximately one sixth to one third the time required at present.

SOME NEW TYPES OF PLEOCHROIC HALOES. F. W. Sparks, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read March 11, 1935). Description and measurements of new types of haloes, particularly in a biotite from Star Lake, Manitoba, are given.

NOTES ON THE CRITERIA FOR DETERMINING THE TOPS OF STRATIFIED BEDS. H. R. Belyea, Dept. of Geology, Dalhousie Univ., Halifax, N. S. (Read May 3, 1935). It is often difficult to determine whether a series of beds is showing the original order of superposition. There are several useful criteria which may prove helpful. The occurrence of cross-bedding, graded bedding, ripple mark, and rain prints preserved in sediments, the bending of the laminae around a pebble in a conglomerate, drag-folding, and cleavage developed in a slate are all of use in determining the tops of beds. The inclination of a pegmatite dyke may be recognized. When the dip is inclined the coarse crystallization favours the hanging wall, and when the dip is vertical the coarse crystallization is in the centre. In a lava the top of the bed is scoriaceous and the bottom chilled.

SILICOSIS: ITS IMPLICATIONS AND IMPORTANCE. Philip Isaacson and Edwin D. Levittan, Dept. of Geology, Dalhousie Univ., Halifax, N. S. (Read May 3, 1935). The close connection of the fields of geology and medicine is positively illustrated by their interrelation in the problems of silicosis. The implications of silicosis in geology are the studies of the rocks and minerals, in man's external environment, which are the causative agents. The implications in medicine are the concomitant and resultant diseases which develop from excessive intake of injurious dusts, the pneumoconioses and tuberculosis. Importance of silicosis is soon realized when the increasing death rate and our present inability to control it are considered. Prevention, although in the early stages, also emphasizes the necessity for studying geology and medicine together. The former investigates dust from its formation to its contact with the nasal membranes. Medicine considers the effects of dust on man after it has entered the nares and studies (1) prevention of silicosis, if possible, and (2) prevention of complicating tuberculosis in silicotics. The present status of silicosis leaves yet much to be desired as regards knowledge of causes, cure and prevention. Prognosis is both good and bad depending on how early the condition is discovered and treated.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper should be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½ x 11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review". A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, (7) **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76 (1927); C. A., **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts". In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**. vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper or on tracing linen. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. The Institute bears the expense of a limited number of cuts only. Where necessary half-tones for reproduction on special paper will be accepted at the author's expense.

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The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOL. XIX. 1935-1936 PART 2

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PROCEEDINGS
OF THE
Nova Scotian Institute of Science

SESSION OF 1935-1936
(Vol. XIX, Part II)

SCHIZOPORELLA UNICORNIS—A BRYOZOAN NEW TO CANADA.

D. PELLUET and F. R. HAYES.
Zoological Laboratory, Dalhousie University, Halifax, N. S.

(Received November 4, 1935).

ABSTRACT.

Two colonies of *Schizoporella unicornis*, growing on a stone, were collected from the rocky coast at Eastern Passage, N. S., at low tide level, on July 22, 1935. This constitutes the first record for this form in Canada, although its distribution ranges from the Arctic Ocean to the southern Atlantic Ocean. An illustration is given emphasizing the characteristic features of this Bryozoan, which differs slightly from the typical southern form.

The marine invertebrate fauna of the Nova Scotian coast has been investigated at various periods, starting with Sir William Dawson, who collected from 1835-1882. Complete lists of the animals were never published but scattered references to existing forms occur in his papers on geology. In 1873, the Challenger Expedition carried out dredging operations off the coast of Nova Scotia and the results were published in the zoological reports of the expedition. In addition to these, several American collectors compiled check lists of the marine fauna.

In 1901 J. F. Whiteaves of the Geological Survey of Canada published the most complete check list of marine invertebrates of Eastern Canada and this is still the most useful reference for a collector in this region. More recently the publication of the Biological Survey of the Mount Desert Region[1] is of interest, since the marine fauna of that region of the coast is very similar to that of Nova Scotia. In that publication, the Bryozoa have been reported by Dr. R. C. Osburn.

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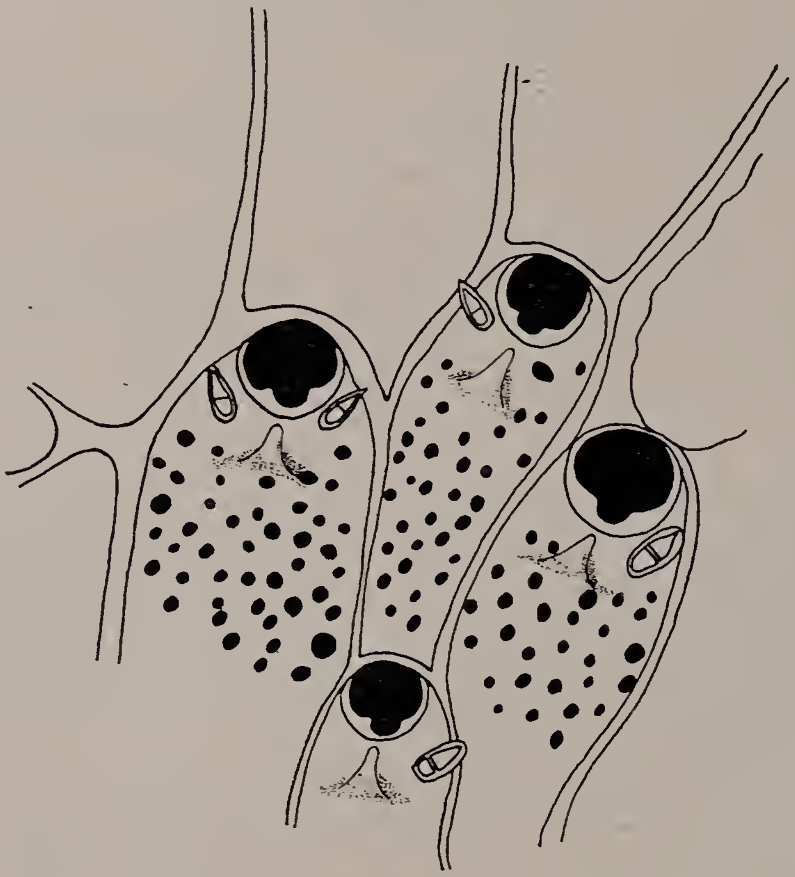
[1] Procter. "*Mount Desert Region Survey*" Wistar Institut. Press. **1933.**

In a series of collections of marine invertebrates which was made this summer, in the region of Halifax harbour, it was not surprising that most of the animals could be identified as forms already listed by Whiteaves or by the Mount Desert Survey. It was with some degree of pleasure that at least one form, viz., *Schizoporella unicornis*, was collected which was not listed by Whiteaves and concerning which Osburn says: "On the Atlantic coast of North America it occurs abundantly from Cape Cod to Florida, and it has been reported from Greenland waters a number of times and from other places in the Arctic, so it is difficult to explain why it seems to run out north of Cape Cod and why it has not been recorded for Eastern Canada." Osburn notes also that *Schizoporella unicornis* is rare in the Mount Desert Region,



Schizoporella Unicornis.

only one colony having been found. Pratt[2], in his "Manual of Common Invertebrate Animals" gives the distribution of Schizoporella as "South Carolina to Massachusetts Bay," as well as a drawing of the animal, which shows some slight differences from the Eastern Passage specimen.

To make certain that there was no mistake in identification, the rock was sent to Dr. Osburn, who confirmed the genus and species; adding, in a letter, that this colony differed slightly from the more southern form. The illustration, which is a somewhat diagrammatic representation of the details of the anatomy, will serve to emphasize its characteristic form, particularly the cylindrical shape of the zooecia, and the unilaminar zoarium, which constitutes the difference between this form and the normal one described by Osburn.

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[2] Pratt. "*Manual of Common Invertebrate Animals*", Blakiston, Phila. **1935.**

THREE RARE FISH FROM PASSAMAQUODDY BAY, N. B.

R. H. M'Gonigle and M. W. Smith.
Atlantic Biological Station, St. Andrews, N. B.

(Received February 10, 1936).

ABSTRACT.

Isurus nasus (Bonnaterre), *Tautoga onitus* (Linnaeus), and *Prionotus carolinus* (Linnaeus) are reported from Passamaquoddy Bay, New Brunswick, 1934-1935.

The recent occurrence in Passamaquoddy Bay of three species of fish, which have visited its waters very rarely, indicates, possibly, some alteration in the ecological conditions of the Bay of Fundy waters, which serve ordinarily as an effective barrier to these fish which occur more plentifully to the south and east.

Isurus nasus (Bonnaterre). Mackerel shark. A specimen, 8.0 feet long, was captured in a herring weir (A. Thurber) just outside St. Andrews harbour on Oct. 3, 1935. The only other record is that of a specimen[1] probably captured in the Passamaquoddy Bay region and brought to the Biological Station at St. Andrews in Aug. 1900.

Tautoga onitus (Linnaeus). Tautog. Two specimens were taken in a herring weir (Gilman) at Oak Bay, a tidal tributary to the St. Croix River, one in the summer of 1934 and the other Aug. 5, 1935. This latter was 53 cm. long and weighed 3.6 kg. after preservation for about three months in formalin. Huntsman[2] writes: "Except for a single specimen taken in Passamaquoddy Bay in 1909 or 1910, there is no evidence of its normally entering the Fundy region."

Prionotus carolinus (Linnaeus). Sea-robin. A specimen was captured in a herring weir (S. Mallock) at St. Andrews on Oct. 2, 1935. It was 30 cm. in length and weighed 274 gms. after preservation in formalin for over a month. Huntsmanf[2] reports a single specimen secured at Campobello Island during Aug. 1911.

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[1] Prince and MacKay. *Contr. Canad. Biol.* **1901**. 55-58 (1901).

[2] Hunstman. *Contr. Canad. Biol.* **1921** (1922). No. 3, 49-72 (1922).

LIVERWORTS AND MOSSES OF NOVA SCOTIA.

MARGARET S. BROWN.
Halifax, N. S.

(Received March 4, 1936).

ABSTRACT.

The bryophyte flora of Nova Scotia shows an unusually wide range. A list is given of 127 hepatics and 367 mosses, making a total of 494 species found in the Province.

The bryophytes of this Province present features of the deepest interest. It is true that the majority of moss species are rather too small to attract general notice, but to the student, armed with pocket-lens and microscope, they open up a new and varied field of beauty.

As in the case of the phaenogams, the Nova Scotian list of mosses shows an unusually wide range. In 1870, the N. S. Institute of Science published Dr. Lindsay's "List of N. S. Plants," which attracted wide attention. The New England botanists were sceptical of some of the species listed; they pointed out, for example, that *Ilex glabra*, the Inkberry, belonged rightly in Louisiana, and had never been seen north of New Jersey,—how then could it be found in Nova Scotia! Yet here it grows, with many another Southern species not yet discovered in Dr. Lindsay's time, *Lophiola, Sabbatia,* etc. On the other hand, also within the limits of our small Province, are found plants belonging to the Arctic Flora. The same is equally true of our mosses, species being found that belong much farther south, others from Greenland, Labrador, and Alaska; and it is a curious fact that still other species, found only on mountain-tops in New England, with us are luxuriating near the sea level. Nova Scotia will thus be seen to provide many surprises.

The first to collect mosses in our Province was Dr. A. H. MacKay, distinguished in almost every branch of Natural Science, and especially in Botany. His collection of mosses he sent to the Department of Botany in Ottawa, and Dr.

Macoun found them of such interest that he himself devoted two summers to Nova Scotia, in 1883, and again in 1898, and formed a greatly increased collection. He was followed by Dr. G. E. Nichols of Yale University, who worked in Cape Breton for four summers, between 1909 and 1916 and added many more species to the list. In 1921 the present writer took up the work but let no one imagine it finished with the publication of the present list; so much ground remains unexplored that it is much to be hoped that other amateurs may be enlisted to carry on.

The collections made by Dr. Macoun and Dr. A. H. MacKay are preserved in the Department of Botany Museum in Ottawa and are listed in Parts VI and VII of Macoun's Canadian Plants. The mosses discovered by Prof. G. E. Nichols are in the herbarium of Yale University. His lists were published in the Bryologist, vol. XIX, pp. 38-47 (1916) and vol. XXI, pp. 28-29 (1918). Mosses collected by M. S. Brown are in Halifax and may be seen at 36 Kent Street. The list appeared in the Bryologist, vol. XXXII, pp. 50-56 (1929).

The Hepatics are given in the order used in McVicar's "Handbook", 2nd Edition, 1926; the mosses follow the order in Dixon's "Handbook of British Mosses", 3rd Edition, 1924. Hepatics 127. Mosses 367. A total of 494 species. Abbreviations:—col. = collector; det. = determined by—; ver. = verified by—.

HEPATICAE.

MARCHANTIALES.

Riccia arvensis, Aust. (= *R. bifurca* Hoffm.)

Lake Annis, Yarmouth Co., July 10, 1935, col. M. S. Brown, no. 303^H. On damp clay footpath. First record for N. S.; Macoun lists it from Hull, Quebec. Ver. W. C. Nicholson.

Conocephalum conicum (L.) Dum.

Margaree, July 1898, col. Macoun; St. Croix; Ellershouse, etc. Not rare, on damp shaded rocks.

Preissia quadrata (Scop.) Nees.

Truro, and Grand Narrows, July 1898, col. Macoun. Most frequent on limestone. May be seen growing and fruiting on mortar of old walls, Martello Tower, Hfx. Park, and on York Redoubt.

Marchantia polymorpha L.

Truro, col. Macoun. Common all over the Province. A conspicuous, handsome growth.

JUNGERMANNIALES.

ANACROGYNAE.

Aneura Dum. (= *Riccardia* S. F. Gray).

Aneura pinguis (L.) Dum.

Barrasois, Vict. Co., July 1915, col. Nichols, no. 1203. Not rare in N. S. on boggy ground; Lake Midway, Digby Co.

Aneura latifrons Lindb.

Baddeck, July 1898, col. Macoun; Margaree; Hubbards. Not rare.

Aneura multifida (L.) Dum.

Barrasois, Vict. Co., 1915, col. Nichols, no. 1334 b; Lawson Mill Rd., Hfx., 1923; and Tuft's Cove; col. M. S. B. no. 269.

Aneura sinuata (Dicks.) Dum.

Barrasois, Vict. Co., col. Nichols, no. 199; also Ingonish Barrens; Peggy's Cove, Hfx. Co.; Ship Harbour; M. S. B., no. 291, det. W. E. Nicholson.

Aneura palmata (Hedw.) Dum.

Truro, col. Macoun; Lake Kedji, July 1926, col. M. S. B., no. 260, det. Conklin. On rotten stumps and logs.

Metzgeria furcata (L.) Dum.

Indian Brook, Vict. Co., 1909, col. Nichols;[1] Port Mouton, col. M. S. B., no. 254. In small patches on trunks of trees, rarely on rocks.

Metzgeria crassipilis (Lindb.) Evans.

Sheet Harbour, Oct. 1923, col. M. S. B. no. 272, det. Evans; again at Ship Harbour Lake; at Lake Annis, Yarmouth Co. On beech trees; new to Canada; a Southern species.

Pallavicinia Lyellii (Hook.) Gray.

Barrasois, col. Nichols, no. 1169; Halifax, col. M. S. B., no. 252; Blomidon; Port Mouton. Not rare.

Pallavicinia Flotowiana (Nees.) Lindb.

Lake Midway, Digby Neck, Aug. 1926, col. M. S. B. no. 283, det. Evans.

Pellia epiphylla (L.) Corda.

Louisbourg, col. Macoun; Halifax; Baddeck; etc. Common. After a wet year, great patches of it, fruiting, have been seen in Halifax Public Gardens in early spring.

Pellia Fabroniana Raddi.

Ingonish, 1914, col. G. E. Nichols, no. 722. Only in 3 stations in New England.

Pellia Neesiana (Gottsche) Limpr.

Ingonish, 1914, Nichols, no. 704. In 4 stations in New England.

Blasia pusilla.

Halfway Brook, C. B., Aug. 1898, col. Macoun; Port Mouton, Advocate, etc. On damp road-sides, not rare.

Fossombronia foveolata Lindb.

Aspy Bay, 1909, Nichols, no. 075; Windsor Jc; Port Joli; Folleigh Mt; col. M.S.B., no. 247, det. Evans. Frequent on lake margins.

ACROGYNAE.

Marsupella emarginata (Ehrh.) Dum.

Margaree, Aug. 1898, col. Macoun; Halifax Arm. Very common on, stones in brooks.

M. sparsifolia (Lindb.) Dum.

Aspy Bay, 1932, col. M. S. B., no. 295, det. W. C. Nicholson.

M. ustulata Spruce.

Barrasois, Vict. Co., 1914, col. Nichols, no. 509.

M. aquatica (Lindb.) Schiffner.

Barrasois, Vict. Co., 1915, col. Nichols, no. 1500; Aspy Bay, col. M. S. B. 1932, no. 296; also Advocate.

M. sphacelata Lindb.

Yarmouth, 1883, col. Macoun; also Halfway Brook, C. B.

These last four species all very rare, alpine and subalpine.

Alicularia scalaris Corda. (= *Nardius* Gray).

Arichat, C. B., col. O. D. Allen;[1] Ferguson's Cove, Hfx. and Five Islands, col. M. S. B., no. 263. Grows in dense mats on low cliffs near the sea.

A. Geoscyphus De Not.

Musquodoboit River, Aug. 1926, col. M. S. B., no. 286, det. Conklin; also at Jeddore. On damp rocks. Earlier specimens in Yale Museum.

A. Geoscyphus var. suberecta.

Musquodoboit, Aug. 1926, col. M. S. B., no. 294, det. Conklin. Growing near the typical form.

Eucalyx obovatus (Nees) Breidl. (= *Nardia*).
Barrasois, 1915, col. Nichols, no. 1445; Aspy Bay, 1932, col. M. S. B., no. 293, det. H. H. Knight.

E. subellipticus (Lindb.) Breidl.
Barrasois, 1915, col. Nichols, nos. 1269 & 1478; Ingonish Mts., no. 1725. These two species are alpine and subalpine, found in Greenland and on Mts. of New England.

Aplozia crenulata (Sm.) Dum. (= *Nardia* Lindb.).
Truro, June 1883, col. Macoun; Baddeck, col. Nichols. Very common all over the Province; often on roadsides in damp situations.

Aplozia cordifolia Dum. (=*Jungermannia* Hook.).
Big Intervale, Margaree, July 1898, col. Macoun; also col. Nichols, in C. B.

Aplozia pumila (With.) Dum.
St. Croix, July 1923, col. M. S. B., no. 274, det. A. W. Evans.

Aplozia lanceolata (Schrad.) Dum.
Margaree, July 1898, col. Macoun; Sandy Cove, Digby Co, and Blomidon, col. M. S. B., no. 214.

Jamesoniella autumnalis (D. C.) Steph.
Margaree, July 1898, col. Macoun; Pictou; Truro. Common in woods, on rocks and even on trees.

Jamesoniella heterostipa Evans.
Barrington Passage, July 1910, col. Macoun, no. 52, growing on stones in a brook. New species, description in Bryologist Sept. 1915.

Gymnocolea inflata (Huds.) Dum. (=*Lophozia inflata* Howe.)
Louisbourg, July 1898, col. Macoun.
Rather common all over the Province in boggy spots.

Lophozia Badensis (Gottsche) Schiffn.
Ingonish, 1914, col. Nichols, no. 715.

L. Kaurini (Limpr.) Steph.
Aspy Bay, 1914, col. Nichols, no. 1722; also on Ingonish Mts.

L. longidens (Lindb.) Macoun.
Cape Smoky, Aug. 1898, col. Macoun; also col. Nichols. Rare.

L. ventricosa (Dicks.) Dum.
Baddeck, July 1898, Macoun. Our most common species of Lophozia, abundant on damp rocks around Halifax.

L. porphyroleuca (Nees) Schiffn.
Barrasois, Vict. Co., 1914, col. Nichols, no. 300; Musquodoboit.

L. alpestris (Schleich.) Evans.

Barrasois, 1915, col. Nichols, no. 1371; Purcell's Cove, M. S. B., no. 219, and Halibut Cove, Hfx. Co.

L. bicrenata (Schmid.) Dum.

Jollimore's, Hfx. Co., col. M. S. B., no. 266, Sept. 1923, det. A. W. Evans. New to N. S., found in New England also.

L. excisa (Dicks.) Dum.

Halifax Park, July 1930, col. M. S. B.,no. 292, det. Conklin. New to N. S.

L. incisa (Schrad.) Dum.

Truro, 1898, col. Macoun; also Louisbourg; Margaree; Port Mouton. Not rare, growing on rotten wood in shade.

L. quinquedentata (Huds.) Cogn.

Margaree, July 1898, col. Macoun; Aspy Bay, 1932, col. M. S. B., no. 297, growing on limestone. Subalpine species.

L. lycopodioides (Wallr.) Cogn.

Pirate's Cove, Straits of Canso, col. Macoun; Truro Park, Oct. 1928, col. M. S. B., no. 290. Alpine species, on rocks. Plentiful in the Rocky Mts., sparingly found over Labrador and across Canada.

Lophozia Hatcheri (Evans) Steph.

Lake Kedji, July 1926, and at Maitland Falls, Annap. Co., Aug. 1934, col. M. S. B. no. 299, det. W. E. Nicholson. Alpine species, on rocks; widely spread but uncommon.

L. attenuata (Mart.) Dum.

Pictou; Baddeck, July 1898, col. Macoun; Halifax Dingle; Ferguson's Cove. Not rare; on rocks, subalpine.

L. barbata (Schmid.) Dum.

Cape Breton, "in brooks and ravines," July 1898, col. Macoun; Ship Harbour; Ellershouse; Port Mouton; col. M. S. B.

L. Kunzeana (Hüb.) Evans.

Tiverton, Digby Co., July 1926, col. M. S. B., no. 304, ver. W. C. Nicholson. Alpine species and very rare. New to N. S.

L. Binsteadii (Kaalaas) Evans.

Barrasois, 1915, col. G. E. Nichols, no. 1431b. New to N. S.

Sphenolobus minutus (Crantz) Steph.

Cape Smoky Mts., Aug. 1898, col. Macoun; Ship Harbour Lake, col. M. S. B., no. 218; Sandy Cove; Dartmouth Lakes; Purcell's. Subalpine, on damp rocks, uncommon and small plant.

S. exsectus (Schmid.) Steph.
Halfway Brook, Cape Breton, 1898, col. Macoun; Lake Charlotte, Guys. Co.; MacNab's Is., Hfx.; Folleigh Mt., col. M. S. B., no. 284. Subalpine, on logs and rocks.

S. exsectiformis (Breidl.) Steph.
Ship Harbour Lake, Guys. Co., Aug. 1924, col. M. S. B., no. 206. New to N. S. Later found at Herring Cove, Hfx., and Dartmouth Barrens. Subalpine and uncommon.

S. Hellerianus (Nees) Steph.
Barrasois, 1909, col. G. E. Nichols. On decaying logs, subalpine and very rare.

S. Michauxii (Web.) Steph.
North West Arm, Hfx., col. Macoun; Barrasois, col. Nichols, no. 263. On rotten wood.

Plagiochila asplenioides (L.) Dum.
Margaree, July 1898, col. Macoun; Yarmouth; Truro. Common all over the Province, on rocks and banks of streams.

P. asplen. forma laxa Schiffn.
Dartmouth Barrens, Sept. 1923, col. M. S. B.

Leptoscyphus Taylori (Hook.) Mitt. (=*Mylia* Gray).
Pirate's Cove; Straits of Canso, col. Macoun; also at Margaree; and Louisbourg; Kearney's Road, Hfx., col. M. S. B. Subalpine, on wet banks.

L. anomalus (Hook.) Mitt.
Barrasois, 1914, col. Nichols, no. 461; Halifax Co., col. M. S. B., no. 255. Common in bogs, among Sphagnum and other mosses.

Lophocolea heterophylla (Schrad.) Dum.
Baddeck, July 1898, col. Macoun; Halifax; Yarmouth. Common everywhere, and often found fruiting, on damp logs and stumps.

Lophocolea minor Nees.
French River, Vict. Co., 1917, col. Nichols; St. Croix, col. M. S. B., no. 242; also at Port Mouton. Always on limestone; widely spread over Canada but uncommon. Leaves erose with gemmae.

Chiloscyphus polyanthus (L.) Corda.
Truro and Margaree, July 1898, col. Macoun. Not rare in wet places, rocks in streams, etc.

Ch. polyanthus var. rivularis (Schrad.) Nees.
Cape Breton, col. Macoun and Nichols.

Ch. poly. v. fragilis (Roth.) K. Müll.
Barrasois, 1915, col. Nichols, no. 1487; Sandy Cove, Aug. 1926, col. M. S. B., no. 258, det. Conklin.

Ch. pallescens (Ehrh.) Dum.
Ingonish and Barrasois, 1914, col. Nichols, no. 721.

Harpanthus scutatus (W. & M.) Spruce.
Pirate's Cove and Margaree, 1898, col. Macoun; Halifax; Lake Charlotte; Port Joli, col. M. S. B. On decaying wood, not rare.

H. scutatus v. uliginosus.
St. Croix, col. M. S. B., no. 273, det. A. W. Evans.

Geocalyx graveolens (Schrad.) Nees.
Margaree and Truro, July 1898, col. Macoun; Bedford; Quarry Lake, Hfx., col. M. S. B., no. 270. On shaded rocky banks.

Cephalozia bicuspidata (L.) Dum.
Pirate's Cove, col. Macoun, July 1883. Common on moist soil everywhere.

C. pleniceps (Aust.) Lindb.
Ingonish Barrens, 1915, col. Nichols, no. 1653b; Purcell's Cove, Hfx., Oct. 1922, col. M. S. B.; also Windsor Jc.; and Melville Park. Alpine species, on moist rock ledges.

C. connivens (Dicks.) Lindb.
Specimen at Yale, or in New York Herbarium, collected in N. S.

Cephalozia Loitlesbergeri Schiffn.
Barrasois, Vict. Co., 1915, col. Nichols, no. 1243b. New to N. America!

C. media Lindb.
Pirate's Cove and Cape Breton, col. Macoun. Frequent, a small delicate plant.

C. catenulata (Hüben.) Spruce.
Truro and Baddeck, July 1898, col. Macoun; Kearney's Road, col. M. S. B.

C. leucantha Spruce.
Barrasois River, 1914, col. Nichols[1], no. 575. New to N. S. This minute plant has once been found in Nfld., also in Alaska and the Pacific slope. On rotten logs.

C. Francisci (Hook.) Dum.
Yarmouth, May 1910, col. Macoun[1], no. 41. This was only the 2nd record for N. America, the first being in Maine, U. S. A., 1902. Found in Northern Europe, but rare. Peggy's Cove, Hfx., Aug. 1927, col. M. S. B., no. 288.

C. fluitans (Nees) Spruce.
Barrasois River, 1914, col. Nichols, no. 201; Port Mouton, col. M. S. B. Common in Sphagnum bogs everywhere.

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[1] Nichols. footnote 1. Bryol 19, 40, (1916).

Nowellia curvifolia (Dicks.) Mitt. (=Cephalozia Dum.).
Pirate's Cove, 1883, col. Macoun; Baddeck; Margaree. Frequent on rotten logs.

Cephaloziella Starkii (Funck) Schiffn. (=C. *byssacea* (Roth) Warnst.)
Barrasois, 1909 & 1915, col. Nichols, no. 1378; St. Croix, col. M. S. B., no. 265, det. Conklin; also Kearney's Rd., Hfx. Very small plant.

C. Hampeana (Nees) Schiffn.
Halifax, Purcell's Cove, and Spion Kop, Sept. 1923, col. M. S. B., no. 264, det. Conklin and Miss C. C. Haynes.

C. elachista (Jack) Schiffn.
Specimen at Yale or N. Y. Botanical Museum, collected in N. S.

Hygrobiella laxifolia (Hook.) Spruce.
Smith's Brook, Cape Breton, 1914, col. Nichols[1], no. 629. Aspy Bay, July 1932, col. M. S. B., no. 298. This last was verified by W. C. Nicholson, who says it is an interesting plant belonging to the Arctic flora. Macoun lists it only from Greenland and Labrador.

Odontoschisma Sphagni (Dicks.) Dum.
Louisbourg, 1898, col. Macoun; Peggy's Cove, Hfx. Co., 1928, col. M. S. B., no. 289. Growing in bog with sphagnum moss.

Odontoschisma denudatum (Nees) Dum.
Pirate's Cove, 1883, col. Macoun; Baddeck; Dartmouth. Growing on rotten wood; not rare.

Calypogeia Trichomanis (L.) Corda.
Baddeck and Margaree, 1898, col. Macoun. Common in Halifax on damp earth, and all over the Province.

C. Neesiana (Massal & Carest.) K. Mull.
Barrasois, 1914, col. Nichols, no. 89; Musquodoboit, 1926, col. M. S. B., no. 287, det. Conklin.

C. fissa (L.) Raddi.
Barrasois, 1915, col. Nichols, no. 1482; Port Mouton, June 1924, col. M. S. B., no. 212, det. Conklin.

C. suecica (Arnell & Perss.) K. Mull.
Ingonish, 1914, col. Nichols, no. 911.

C. Sullivantii Aust.
Ferguson's Cove, Hfx., Sept. 1923, col. M. S. B., no. 262, det. Evans. Small delicate plant, new to N. S. Also at Upper Sackville, Hfx.; Mt. Uniacke; and Lake Annis, Yar. Co.

Bazzania trilobata (L.) Gray.
Halifax, Truro, Baddeck, Margaree, 1898, col. Macoun. Common and large plant, covering mounds and even stumps.

Bazzania denudata (Torrey) Trevis.

Pirate's Cove, 1883; Louisbourg, 1898; Ferguson's Cove, Hfx. Macoun lists these as *B. triangularis*, and Nichols names them *B. tricrenata*, but Evans determines all with caducous leaves and green colouring as *B. denudata*.

Lepidozia reptans (L.) Dum.

Truro and Baddeck, 1898, col. Macoun. Very common on shaded earth and rocks everywhere.

L. sylvatica Evans.

Hubbard, Hfx. Co., Aug. 4, 1935, col. M. S. B., no. 257B, det. W. C. Nicholson who was the first to discover this species growing in Great Britain. New to Canada.

L. setacea (Web.) Mitt.

Barrasois Barrens, 1914, col. Nichols, no. 472; Ferguson's Cove; Hubbard; col. M. S. B. Not uncommon in bogs.

Blepharostoma trichophyllum (L.) Dum.

Pirate's Cove, 1883, Yarmouth, Aspy Bay, 1898, col. Macoun. Not uncommon, very small plant.

Ptilidium ciliare (L.) Hampe.

Cole Harb., 1923, col. M. S. B., no. 245; also Port Mouton. Growing erect, and forming deep tufts.

Pt. pulcherrimum (Web.) Hampe.

Baddeck and Margaree, 1898, col. Macoun; Barrasois, 1909, col. Nichols. Growth prostrate, on tree trunks and on rocks. Common all over the Province.

Trichocolea tomentella (Ehrh.) Dum.

Barrasois, 1909, col. Nichols; Lake Charlotte; Hubbard; Ellershouse, col. M. S. B. Large and handsome, spreading over damp mosses; uncommon.

Diplophyllum albicans (L.) Dum.

Pictou, 1883, Margaree, 1898, col. Macoun; Halifax, 1923, col. M. S. B., no. 208, det. Evans. In shade, on wet rocks.

D. taxifolium (Wahl.) Dum.

Pirate's Cove, 1883, Cape Smoky, 1898, col. Macoun; Sandy Cove, 1926, col. M. S. B.

D. sp?

Cole Harb. Rd., Sept. 1923, col. M. S. B., no. 259. Growing with Anthoceros on damp grassy track.

Scapania nemorosa (L.) Dum.

Cape Breton Is., 1898, col. Macoun. Most common species over the whole Province; on roadsides, etc.; most luxuriant on dripping rocks, growing in reddish cushions.

S. *dentata* Dum.

Barrasois, 1915, col. Nichols, no. 1397; N. W. Arm, Halifax, 1923, col. M. S. B., no. 244, det. Conklin. On stones in brook. Rare in N. America.

S. *undulata* (L.) Dum.

Yarmouth, Halifax, Baddeck, Louisbourg, 1898, col. Macoun. Common on stones in running water.

S. *irrigua* (Nees) Dum.

Truro, col. Macoun, no. 103; Windsor Jc.; Dartmouth Barrens, col. M. S. B., no. 279., det. Conklin.

S. *curta* (Mart.) Dum.

St. Croix, July 1923, col. M. S. B., no. 268, det. A. W. Evans; Windsor; Folleigh Mt. On wet rock ledges.

S. *umbrosa* (Schrad.) Dum.

Barrasois, 1909, col. Nichols; Dartmouth Barrens, July 1924, col. M. S. B.; St. Croix; Maitland River. On decayed wood.

S. *apiculata* Spruce.

Specimen in Yale Herbarium, collected in N. S.

S. *Bolanderi* Aust.

Truro, 1898, col. Macoun, and at Pirate's Cove, 1883.

S. *Oakesii* Aust.

Barrasois, 1914, col. Nichols, no. 294; Ferguson's Cove, July 1923, col. M. S. B., no. 211, det. Conklin.

S. *paludicola* (Loeske) K. Müll.

Barrasois, 1914, col. Nichols, no. 213; Port Mouton, col. M. S. B., no. 280, det. Conklin; Dartmouth Barrens.

S. *subalpina* (Nees) Dum.

Barrasois, 1915, col. Nichols, no. 1370.

Radula complanata (L.) Dum.

Cape Breton Is., 1883, col. Macoun. Common everywhere on bark of trees.

Porella (=*Madotheca* Dum.).

Porella platyphylla Lindb.

Macoun lists this, the most common species in Europe, from Yarmouth, Halifax, and Margaree. Dr. Evans shows that these collections should be transferred to the following species:—

Porella platyphylloidea (Schwein.) Lindb.

Additional stations are Indian Brook, col. Nichols, no. 42; Big Intervale, C. B., col. Macoun, no. 55, & 58; Sandy Cove, col. J. D. Lowe. Common on trees.

P. pinnata L.

Halifax, Old Cobequid Rd., 1923, col. M. S. B., no. 249. On stones in a brook.

Cololejeunea Biddlecomiae (Aust.) Evans.

Port Mouton, Aug. 1923, col. M. S. B., no. 256, det. Evans; Lochaber; Glen Margaret; Cow Bay Run. On rocks, a very small plant.

Lejeunea cavifolia (Ehrh.) Lindb.

Cape Smoky, 1914, col. Nichols, no. 739; and Barrasois, 1909; Port Mouton, 1924, col. M. S. B., no. 253, det. Evans.

Lejeunea patens Lindb.

Big Intervale, Margaree, col. Macoun, July 1898; Sandy Cove, Digby Co., 1926, col. M. S. B., no. 282, det. A. W. Evans. On rock.

Microlejeunea ulicina (Tayl.) Evans.

Sandy Cove, Aug. 1908, col. Mrs. J. D. Lowe. On trees. New to N. America. Found in Ireland and in England.

Frullania eboracensis Gottsche.

Cape Breton Is,. 1898, col. Macoun. Quite common on trees.

Fr. Asagrayana Mont.

Truro, Baddeck, col. Macoun. Very common on trees and rocks.

Fr. Tamarisci (L.) Dum.

Margaree, July 1898, col. Macoun; Port Mouton, Aug. 1924, col. M. S. B., no. 281. Rare in N. America.

Anthoceros laevis L.

Middle River, 1917, col. Nichols, no. 2015; Port Mouton, Aug. 1923, col. M. S. B., no. 239.

A. punctatus L.

Truro, 1883, col. Macoun; Barrasois, col. Nichols; East Chester, col. L. S. Brown.

A. Macounii M. A. Howe.

Cole Harb., Hfx. Co., Sept. 1923, col. M. S. B., no. 276, det. A. W. Evans. New to N. S.

MUSCI.

SPHAGNALES.

SPHAGNACEAE. Peat mosses.

Sphagnum cymbifolium Ehrh. (=S. palustre L.).

Pictou, 1907[1], col. C. B. Robinson; Halifax, col. M. S. B., Sept. 1918. Common in damp grassy places.

S. *papillosum* Lindb.

Barrasois, col. Nichols, no. 206; Truro, 1898, col. Macoun. Frequent in peat bogs; this was the species most used for hospital dressings during the Great War.

S. *Magellanicum* Brid.

Barrasois Barrens, col. Nichols, no. 476; also at Barrasois and at Aspy Bay Barrens.

S. *imbricatum* Russ. var. *cristatum* Warnst.

Louisbourg, col. Macoun.

S. *imbricatum* var. *affine* Warnst.

Truro, col. Macoun.

S. *rufescens* Bry. Germ.

Truro, col. Macoun; and Kingston, N. S.

S. *subsecundum* Nees.

Barrasois, col. Nichols, no. 207; also at Mount Franey.

S. *Pylaisei* Brid.

Aspy Bay, col. Macoun, 1898; Halifax, 1920, no. 309, col. M. S. B.

S. *Pylaisei* var. *sedoides* Lindb.

Grand Lake, Hfx. Co., on gravel shore, Sept. 6, 1924, col. M. S. B., no. 305, det. A. L. Andrews.

S. *teres* Aongstr.

Barrasois, col. Nichols, no. 1164.

S. *squarrosum* Pers.

Barrasois, col. Nichols, no. 0923..

S. *molle* Sull.

Sable Is., 1899, col. Macoun, "quite common there."

S. *tenerum* Sull. Lesq.

Barrasois Barrens, col. Nichols, no. 482; also Ingonish Barrens, and Barrasois.

S. *acutifolium* Ehrh. (=S. *capillaceum* Schaub.).

Cape Smoky, col. Nichols, no. 1763; Annapolis Royal, col. Prof. J. B. Porter, 1918.

S. *acut.* var. *tenellum* A. L. Andrews.

Barrasois, col. Nichols, no. 200; Pictou, col. MacKay, "quite common in N. S."

S. *fuscum* Klingr.

Barrasois Barrens, col. Nichols, no. 465. Quite frequent, in large brown cushions.

S. quinquefarium Warnst.
Barrasois, col. Nichols, no. 0918; Rockingham Woods, Sept. 1918, col. M. S. B., no. 299A.

S. plumulosum var. *flavicomans* (Card.) A. L. Andrews.
Barrasois Barrens, col. Nichols, no. 480.

S. Girgensohnii Russ.
Barrasois, col. Nichols, no. 0925; Rockingham, Hfx. Co., 1918, col. M. S. B., no. 299B.

S. robustum (Russ.) Röll.
Barrasois, col. Nichols, no. 0919.

S. recurvum Beauv. (=*S. intermediu* Hoffm.)
Barrasois, col. Nichols, no. 0920.

S. recurvum var. *amblyphyllum.*
Kingston, N. S., col. Macoun.

S. pulchrum (Lindb.) Warnst.
Barrasois, col. Nichols, no. 203; Williams Lake, Hfx. Co., 1918, col. M. S. B., no. 297C.

S. cuspidatum Ehrh.
Barrasois Barrens, col. Nichols, no. 511; Belcher's Pond, Hfx. Co., 1918, col. M. S. B., no. 298A. Flaccid and delicate.

S. cusp. var. *Torreyanum* (Sull.) Braithw.
Ingonish Barrens, col. Nichols, no. 835; Belcher's Pond, Hfx. Co., 1918, col. M. S. B. Very large and robust.

S. Dusenii (C. Jens.)
Ingonish Barrens, col. Nichols, no. 2001.

S. tenellum. Pers.
Ingonish Barrens, col. Nichols, no. 1670.

ANDREAEALES.

ANDREAEACEAE.

Andreaea petrophila Ehrh.
Truro and Margaree, col. Macoun. Common on rocks near Halifax.

A. petro. var. *alpestris* Schimp.
N. W. Arm, Halifax, June 1883, col. Macoun. On damp rocks. New to America.

A. Rothii Web. & Mohr.
Aspotogan, Oct. 1930, col. M. S. B. no. 479. On damp rocks. New to N. S.

BRYALES.

TETRAPHIDACEAE.

Georgia pellucida Rabenh. (=*Tetraphis* Hedw.).
Margaree, 1898, col. Macoun; Pictou. Common on rotten wood.

G. geniculata Lindb.
Margaree, 1898, col. Macoun; Lake Charlotte, Aug. 1924, col. M. S. B., no. 357.

POLYTRICHACEAE.

Catharinea undulata Web. & Mohr.
Pictou, col. A. H. MacKay; Barrasois, Vict. Co., col. Nichols, no. 0947. Frequent on damp banks; a large showy moss.

C. angustata Brid.
Barrasois & Aspy Bay, col. Nichols, no. 0948 & no. 1022.

C. Haussknechtii Jur. & Milde.
Halfway Brook, C. B., Aug. 1898, col. Macoun.

C. Selwyni Aust.
Margaree, July 1898, col. Macoun.

C. crispa James.
Halibut Cove, Hfx. Co., Oct. 1935, col. M. S. B., no. 545. Not rare in beds of rocky streams, but seldom found fruiting. This collection had abundance of capsules.

Polytrichum brevicaule (Brid.) Beauv. (=*Pogonatum tenue* E. G. B.).
Pictou, col. A. H. MacKay; Baddeck, 1898, col. Macoun. Not rare on damp clay banks.

P. capillare Rich.
Sherbrooke, Guys. Co., 1924, col. M. S. B., no. 315. Found fruiting here, also on Fort Needham, Hfx.; sterile plants not rare at Melville Park, Hubbard, etc.

P. alpinum L.
Louisbourg, Baddeck, Halifax, col. Macoun. Frequent on shaded rocks.

Polytrichum piliferum Schreb.
N. W. Arm, Hfx., col. Macoun; Wreck Cove, C. B. Very common on rocks around Halifax.

P. juniperinum Willd.
Pictou, col. A. H. MacKay. Abundant all over Canada.

P. strictum Banks.
Truro, col. Macoun; Barrasois, col. Nichols, no. 0944; Halifax and Lunenburg Cos.

P. gracile Dicks. var. *anomala* Milde.
Aspy Bay Barrens, 1914, col. Nichols, no. 1002.

P. ohioense R. & C.
Margaree, 1898, col. Macoun; not rare; Louisbourg, Halifax, North Sydney.

P. commune L.
Pictou, col. A. H. MacKay.[1] Abundant all over the Province, on worn out fields and shady banks.

BUXBAUMIACEAE.

Buxbaumia aphylla L.
Pictou, col. A. H. MacKay, at mill dam; Halifax, col. Dr. Lawson; Barrasois, Lake Kedji. Rare and curious plant.

B. indusiata Brid.
Barrasois, 1914, col. Nichols, no. 1. The only collection recorded for N. S. Has been found in B. Columbia.

Diphyscium foliosum Mohr. (= *Webera sessilis* Lindb.)
Halifax, Pictou, col. A. H. MacKay; Margaree, col. Macoun. Another curious plant, but more common than Buxbaumia; on shaded banks in woods.

DICRANACEAE.

Ditrichum tenuifolium Lindb. (= *Trichodon cylindricus* Schimp.)
Half-way House, Cape Breton, Aug. 1898, col. Macoun.

D. tortile Lindb.
Truro, col. Macoun; Barrasois, col. Nichols. Common by roadsides.

D. homomallum (Hedw.) Hampe.
Louisbourg, Aug. 1898, col. Macoun; Margaretville, July 1935, col. M. S. B., on cliffs and crevices, Bay of Fundy shore.

D. vaginans (Sull.) Hampe (= D. *lineare.*)
Grand Narrows and Baddeck, col. Macoun; Folleigh Mt. Rather common.

D. flexicaule Schleich.
Whycocomagh and Margaree, July 1898, col. Macoun.

Ditrichum pallidum (Schreb.) Hampe.
Lake Kedji, July 1926, col. M. S. B., det. H. Dupret; also at Kearney's Lake, Hfx. Co. New to N. S., not reported E. of Ont.

Swartzia montana Lindb. (=*Distichium capillaceum*, B. & S.)
Margaree, 1898, col. Macoun; also col. Nichols, 1914.

S. inclinata Ehrh.
Aspy Bay, 1916, col. Nichols, no. 2014.

Ceratodon purpureus Brid.
Pictou, col. A. H. MacKay. Common especially on burnt ground; the stems of young fruit form bright red patches, which may be seen around Halifax railway terminals.

Rhabdoweisia crispata (Dicks.) Lindb. (=*R. denticulata* B. & S.)
Windsor Jc., July 1923, col. M. S. B., no. 318, det. A. L. Andrews.

Cynodontium polycarpum Schp. (=*Oncophorus* Brid.)
Barrasois, 1915, col. Nichols, no. 1461.

C. Wahlenbergii Ren. & Card.
Truro and Margaree, 1898, col. Macoun. Occasional, on damp shaded rocks.

Dichodontium pellucidum Schp.
Louisbourg, 1898, col. Macoun; Truro Park, 1928, and Sandy Cove, Aug. 1926, col. M. S. B., no. 498, det. Dixon. On wet rocks.

Trematodon ambiguus Hornsch.
Pictou, col. A. H. MacKay; Truro, Louisbourg, Baddeck, col. Macoun; Lake Kedji.

Dicranella heteromalla Schp.
Truro, col. A. H. MacKay; Yarmouth; Louisbourg. Common on clay banks.

D. cerviculata Schp.
Louisbourg, col. Macoun, 1898, and at Halfway Brook; Terence Bay. On wet calcareous earth.[1]

D. varia Schimp.
Truro, col. Macoun; Barrasois, col. Nichols, no. 09154.

D. squarrosa Starke.
Cape Smoky, July 1898, col. Macoun, "in wet springy places."

Blindia acuta (Huds.) B. & S.
Halfway Brook, C. B., Aug. 1898, col. Macoun; Aspy Bay. On rocks in ravines.

Dicranodontium longirostre B. & S.
Louisbourg, Aug. 1898, col. Macoun; Musquodoboit River, 1924, col. M. S. B., no. 343.

Dicranum undulatum Turn.
Baddeck, July 1898, col. Macoun. Common, a large handsome moss in cushions.

D. spurium Hedw.
Margaree, 1898, col. Macoun; N. W. Arm, Hfx. Co.

D. Bergeri Bland.
Halfway Brook, C. B., Aug. 1898, col. Macoun; Louisbourg.

D. Bonjeani De Not.
Indian Brook, C. B., Ingonish and Barrasois, col. Nichols.

D. scoparium Hedw.
Pictou, col. A. H. MacKay; Cape Breton, col. Macoun. Common all over the Province, in cushions.

D. majus Smith.
Baddeck, Margaree, col. Macoun; McNab's Is., Hfx. Rather common.

D. fuscescens Turn.
Pirate's Cove, Straits of Canso, col. Macoun.

D. Mühlenbeckii B. & S.
Ingonish Barrens, 1909, col. Nichols, no. 811.

D. fulvum Hook.
Halifax Co., col. A. H. MacKay; Margaree, 1898, col. Macoun.

D. viride Schimp.
Margaree, Aug. 1898, col. Macoun. Quite common, base of trees and on wood.

D. flagellare Hedw.
Baddeck and Louisbourg, 1898, col. Macoun; Halifax, Feb. 1921, col. M. S. B., no. 443; Oxford Jc.

D. montanum Hedw.
Pictou Co., col. A. H. MacKay. Barrasois, 1914, col. Nichols, no. 197.

D. longifolium Hedw.
Big Intervale, Margaree, and Halfway Brook, C. B., col. Macoun; "very common at those stations."

D. condensatum Hedw.
Ingonish Barrens, col. Nichols, no. 818.

D. consobrinum Ren. & Card.
Pirate's Cove, Canso, col. Macoun.

D. Drummondii C. Müll.
Barrasois, col. Nichols, no. 196.

Leucobryum glaucum Schp.
Pictou, col. A. H. MacKay; Margaree. Common everywhere in whitish cushions in woods.

FISSIDENTACEAE.

Fissidens minutulus Sull.
Pictou, col. A. H. MacKay.

F. osmundoides Hedw.
Pirate's Cove and Margaree, 1898, col. Macoun.

F. adiantoides (L.) Hedw.
Pictou, col. A. H. MacKay; Pirate's Cove and Whycocomagh, col. Macoun.

F. decipiens De Not. (=*F. cristatus*).
Whycocomagh, col. Macoun; Newport; Windsor; Yarmouth. Frequent.

F. taxifolius (L.) Hedw.
Windsor, Oct. 1929, col. L. S. Brown.

GRIMMIACEAE.

Grimmia angusteum (=*Schizidium*).
Sherbrooke, 1924, col. M. S. B., det. Loeske. no. 408.

G. apocarpa Hedw.
Earltown, col. A. H. MacKay; Margaree, on dry rocks, col. Macoun. Frequent.

G. conferta Funck.
Pictou, col. A. H. MacKay; Barrasois, col. Nichols.

G. gracilis Schleich.
Margaree, 1898, col. Macoun; Wolfville, Ellershouse, 1933, col. M. S. B., det. J. H. Albrecht.

G. maritima Turn.
Peggy's Cove, Aug. 1927, col. M. S. B., no. 463. On rocks by the sea; new to N. S.

G. Olneyi Sull.
Lake Kedji, July 1934, col. M. S. B., no. 526, ver. A. J. Grout. New to N. S.

Rhacomitrium aciculare Brid.
Halifax Co., col. A. H. MacKay; Aspy Bay, Aug. 1898, col. Macoun. Frequent on rocks in streams.

Rh. fasciculare Brid.
Cape Smoky and Margaree, 1898, col. Macoun; Lake Charlotte, Aug. 1924, col. M. S. B., no. 394.

Rh. sudeticum B. & S.
Truro, col. Macoun; Ingonish, col. Nichols, no. 1663B.

Rh. sudeticum var. *validius* Jur.
Ingonish, July 1932, col. M. S. B., det. J. H. Albrecht. On rocks by river.

Rh. microcarpon Brid.
Salmon River, Sept. 1932, col. M. S. B., det. J. H. Albrecht, no. 454C.

Rh. affine (Schleich.) Lindb.
N. W. Arm, Hfx., 1883, col. Macoun.

Rh. Nevii C. Müll.
Truro, col. Macoun. On stones in brook.

Rh. robustifolium Kindb.
Halifax Park, July 1898, col. Macoun.

Rh. lanuginosum Brid.
Hfx. Co., col. A. H. MacKay; Ingonish and St. Anne's, 1898, col. Macoun Louisbourg; Peggy's Cove.

Rh. canescens Brid.
Margaree, 1898, col. Macoun; Blomidon, North Mt., 1927, col. M. S. B., no. 386.

Campylostelium saxicola B. & S.
Port Mouton, Queen's Co., July 1924, col. M. S. B., no. 346, det. A. W. Andrews. This minute plant is new to N. S. and grew on a silicious rock. Dr. Macoun collected it on a sandstone boulder in P. E. I. in 1884.

Hedwigia ciliata Ehrh.
Halifax; Yarmouth; Cape Breton. Common on rocks all over the Province.

TORTULACEAE.

Pottia truncatula (L.) Lindb.
East Chester, Nov. 1926, col. L. S. Brown, no. 433.

Tortula ruralis Ehrh.
Aspy Bay, July 1917, col. Nichols, no. 1807.

T. mucronifolia Schwaeg.
Truro, col. Macoun; Aspy Bay, col. Nichols, no. 2008.

Barbula unguiculata Hedw.
Pictou, col. A. H. MacKay; Baddeck, 1898, col. Macoun; Windsor; Purcell Cove, Hfx. Co.

B. sp?
Margaree, Sept. 1933, col. L. S. Brown, no. 515.

B. rubella Lindb. (=*Didymodon rubellus*)
Truro and Halfway Brook, C. B., col. Macoun, Truro Park and Folleigh Mt., col. M. S. B.

Tortella tortuosa (L.) Limpricht (=*Trichostomum* Dixon.)
Cow Bay Run, Hfx. Co., col. M. S. B., no. 489; St. Croix; Dingwall. On calcareous soil.

T. caespitosa (Schwaeg.) Limpricht.
Boulardrie, C. B., Oct. 1920, col. M. S. B., no. 310, det. E. G. Britton; St. Croix. New to N. S.

Weisia viridula Hedw.
Barrasois, 1909, col. Nichols, no. 09150; Halifax, col. M. S. B., no. 441. Very small plant, not rare.

W. calcarea (C. M.) Nees & Hornsch.
Pictou, col. A. H. MacKay; Windsor; Newport.

W. rupestris C. M.
Pictou, col. C. B. Robinson, 1907[1].

W. curvirostris C. M.
Cape Dauphin, 1914, col. Nichols, no. 595.

W. tenuis C. M. (=*Gymnostomum pusilla* Kindb.)
Grand Narrows, 1898, col. Macoun. On earth in ravine.

ENCALYPTACEAE.

Encalypta ciliata Hoffm.
Barrasois, 1914, col. Nichols, no. 1470.

E. streptocarpa Hedw. (=*E. contorta* Lindb.)
Margaree, 1898, col. Macoun; North Sydney, 1922, col. M. S. B., no. 516.

ORTHOTRICHACEAE.

Zygodon lapponicus B. & S.
Margaree, July 1898, and Truro, col. Macoun.

Z. Mougeotii B. & S.
Margaree, July 1898, col. Macoun; Lake Charlotte, Guys. Co., Aug. 1924, col. M. S. B., no. 340.

Z. conoideus Hook. & Tayl.
Sheet Harb., July 1924, col. M. S. B., no. 456, det. Cheney; Lake Kedji; Lake Annis, Yar. Co. Very rare in N. America. New to Canada.

Z. Sullivantii (L. & J.) C. Müll. (=*Leptodontium excelsus*)
Halfway Brook, C. B., Aug. 1898, col. Macoun.

Drummondia clavellata Hook.
Milton, Queens Co., Sept. 1929, col. M. S. B., no. 474. On old willow tree. New to N. S.

Ulota Ludwigii Brid.
Pictou, col. A. H. MacKay; Whycocomagh. Quite common on trees all over the Province.

U. Drummondii Brid.
Big Intervale, Margaree and Halfway Brook, 1898, col. Macoun.

U. crispa Brid. (= *U. ulophylla*)
Pictou, col. A. H. MacKay; Truro; Margaree. Frequent on trees.

U. intermedia Schimp.
Baddeck, July 1898, col. Macoun. Frequent on trees.

U. crispula Brid.
Pictou, col. A. H. MacKay. Often found on trees.

U. phyllantha Brid.
Louisbourg, July 1883, col. Macoun; also at Yarmouth. Rare species, on trees.

U. maritima C. M. & Kindb.
Big Intervale, on boulders in the Margaree River, July 1898, col. Macoun.

U. Americana (Beauv.) Limpr.
Truro, col. Macoun; Barrasois, col. Nichols, no. 1345.

Orthotrichum rupestre Schleich.
Margaree, July 1898, col. Macoun.

O. speciosum Nees.
Pictou, col. A. H. MacKay; Annapolis, col. M. S. B., no. 459, det. L. S. Cheney.

O. affine Schrad.
Baddeck, July 1898, col. Macoun. On trees.

O. affine var. *fastigiatum* Bruch.
Margaree, 1898, col. Macoun. On trees.

O. strangulatum Beauv.
Pictou, col. A. H. MacKay; Annapolis Royal, on trees, Aug. 1926, col. M. S. B., no. 447, det. L. S. Cheney.

O. sordidum Sull. & Lesq.
Annapolis Royal, Aug. 1926, col. M. S. B., no. 446, det. L. S. Cheney.

O. obtusifolium Schrad.
Margaree, July 1898, on poplar trees, col. Macoun; Musquodoboit, Tatamagouche, col. M. S. B.

SPLACHNACEAE.

Splachnum ampullaceum L.

North Sydney, Baddeck, 1898, & Canso, col. Macoun; Pt. Mouton; Lake Annis, Yar. Co. On cow dung in bogs and damp woods.

Tetraplodon australis Sull. & Lesq.

Isle Madame, col. J. A. Allen.

T. angustatus Sw. B. & S.

Ingonish Barrens, 4 collections, col. Nichols, no. 827 & 1632; Lake Kedj, col. M. S. B., no. 522.

T. bryoides (Zoeg.) Lindb.

Barrasois and Ingonish Barrens, col. Nichols, no. 493 & 824. The Tetraplodon mosses are found on animal droppings in woods. Rare

Tayloria tenuis Schp.

Pirate's Cove, 1883, col. Macoun; Tiverton, July 1926, col. M. S. B., no. 366; Baddeck, 1898, col. Macoun.

FUNARIACEAE.

Physcomitrium turbinatum (Mx.) Brid.

Halifax, May 1925, col. L. S. Brown, no. 434. Elderbank; Falmouth.

Entosthodon neoscoticus M. S. Brown Nov. sp.

Peggy's Cove, Hfx. Co., Sept. 19, 1928, col. M. S. B., no. 485, det. E. G. Britton. This new species combines characteristics of Funaria with those of Physcomitrium. Description in Bryologist, March 1932, vol. XXXV, p. 17-18 and on p. 48.

Funaria hygrometrica Sibth.

Pictou, col. A. H. MacKay; Baddeck; Yarmouth. Common on burnt land everywhere, and on stone walls.

MEESIACEAE.

Meesia trichoides Spruce.

Truro, in bogs, col. Macoun.

Aulacomnium palustre Schwaeg.

Pictou, col. A. H. MacKay; Baddeck; Yarmouth. Common on damp ground.

A. androgynum (L.) Schwaeg.

Pirate's Cove, col. Macoun; Barrasois, col. Nichols, no. 0937;Port Mouton; Lake Charlotte.

A. heterostichum B. & S.

St. Croix, July 1923, col. M. S. B., no. 317; Aspy Bay, col. M. S. B., no. 496, det. Andrews. New to N. S.; reported also from Ontario.

BARTRAMIACEAE.

Bartramia Oederi Schwartz.
Margaree, 1898, col. Macoun; Cape Breton; Straits of Canso; Truro.

B. pomiformis (L.) Hedw.
Pictou, col. A. H. MacKay; Barrasois, C. B., col. Nichols, no. 0992. Frequent in rocky ravines.

B. crispa Schwartz.
Margaree and Grand Narrows, col. Macoun. Dixon makes this merely a variety of *B. pomiformis*.

Philonotis fontana Brid.
Pictou, col. A. H. MacKay; Margaree. Common everywhere in wet springy places, roadsides, etc.

Ph. Marchica (Willd.) Brid.
Aspy Bay Mts., col. Nichols, no. 1004.

Ph. americana Dismier.
Northern Cape Breton, col. Nichols[1].

BRYACEAE.

Leptobryum pyriforme Wils.
Pictou, col. A. H. MacKay. Frequent all over the Province.

Webera elongata Schwaeg. (=*Pohlia* Hedw.)
Lake Charlotte, Guys. Co., Aug. 1924, col. M. S. B., no. 324, det. Andrews.

Webera cruda Schwaeg.
Pirate's Cove and Margaree, 1898, col. Macoun.

W. nutans Hedw.
Pictou, col. A. H. MacKay; Barrasois, col. Nichols. Very common everywhere throughout the Province.

W. annotina Schwaeg.
Pictou, col. A. H. MacKay; Halifax and Herring Cove, col. M. S. B.

W. proligera Bryhn.
Sandy Cove, Aug. 1926, col. M. S. B., no. 335.

W. pseudo-carnea Kindb.
Sable Is., col. Macoun.

W. carnea Schimp.
Truro, col. Macoun.

W. albicans Schp.
Pictou, col. A. H. MacKay; Windsor; Lake Charlotte, 1924, col. M. S. B.

W. lescuriana L. & J. (= *W. pulchella* Schimp.)
Truro, col. Macoun; Purcell Cove, col. M. S. B., no. 314, det. A. L. Andrews; Beaver Bank.

W. sphagnicola Schimp.
Kingston, N. S., in a peat bog, col. Macoun.

Bryum pendulum Schimp.
St. Croix, col. M. S. B., no. 403F, det. A. L. Andrews.

B. inclinatum B. & S.
Truro, col. Macoun; Aspy Bay and Cape North, col. Nichols, no. 2012 & no. 1805.

B. uliginosum B. & S.
Boulardrie, Oct. 1920, col. M. S. B., no. 311, det. C. G. Britton.

B. pallens Sw.
Grand Narrows, 1898, col. Macoun; St. Croix, col. M. S. B., no. 392, det. Andrews. Ferguson's Cove, Hfx.

B. fallax Milde.
Barrasois, col. Nichols, no. 1806.

B. Duvalii Voit.
Barrasois, col. Nichols, no. 389.

B. cyclophyllum B. & S.
Barrasois, col. Nichols, no. 1304.

B. pseudo-triquetrum Schwaeg. (=*B. ventricosum* Dicks.)
Margaree, 1898, col. Macoun; Lake Charlotte, 1924, col. M. S. B., no. 355, det. Andrews.

B. bimum Schreb.
Hfx. & Pictou Cos., col. A. H. MacKay; Aspy Bay, col. Nichols, no. 1044.

B. affine Lindb.
St. Croix, July 1923, col. M. S. B., no. 403D, det. Andrews.

B. affine var. *cirratum* Braithw.
St. Croix, col. M. S. B., no. 403B, det. Andrews.

B. pallescens Schleich.
Grand Narrows and Halfway Brook, C. B., col. Macoun; also col. Nichols, in C. B.

B. intermedium Brid.
Truro, col. Macoun.

B. caespiticium L.
Halifax and Pictou Cos., col. A. H. MacKay. Very common everywhere and, as it fruits freely, often collected.

B. capillare L.

Pictou, col. A. H. MacKay; Barrasois, col. Nichols, no. 09136; Port Mouton, col. M. S. B.

B. erythrophyllum Kindb.

Truro, 1883, col. Macoun. This species is close to *B. obtusifolium* found in Greenland.

B. acutiusculum C. Müll.

Summit of Cape Smoky, Aug. 1898, col. Macoun.

B. Knowltoni Barnes.

Sable Is., "not uncommon," col. Macoun; also found in Nfld.

B. Raui Aust.

Truro, col. Macoun.

B. torquescens B. & S.

Truro, col. Macoun. Dixon makes this a var. of *B. capillare.*

B. argenteum L.

Truro, col. Macoun; North Sydney; Yarmouth. Widely spread over N. S.

Rhodobryum roseum Schreb.

Boulardrie, Oct. 1920, col. M. S. B., det. E. G. Britton, no. 307B; also at Aspy Bay, 1932.

Mnium affine Bland.

Pictou Co., col. A. H. MacKay; Whycocomagh, col. Macoun.

M. ciliare Grev.

St. Croix, July 1923, col. M. S. B., no. 444; Big Intervale, Margaree, 1898, col. Macoun.

M. cuspidatum Hedw.

Pictou, col. A. H. MacKay. Barrasois and Ingonish, col. Nichols. Common everywhere, base of old trees, banks in woods, etc.

M. hornum L.

Pictou Co., col. A. H. MacKay. Very common on banks of streams, throughout the Province.

M. serratum Schrad. (=*M. marginatum* Beauv.)

Barrasois, col. Nichols, no. 638; Lochaber, Guys. Co., 1924, col. M. S. B., no. 330, det. H. Dupret.

M. orthorrhynchum B. & S.

Pirate's Cove, Canso, col. Macoun; Ingonish, col. Nichols, no. 710.

M. pseudo-lycopodioides C. M. & Kindb.

Pirate's Cove, col. Macoun.

M. stellare Reich.

Margaree, 1898, col. Macoun; St. Croix and Oakfield, Hfx. Co., June 1924, col. M. S. B., no. 445, det. H. Dupret.

M. cinclidioides Huebn.
Ingonish and Barrasois, col. Nichols, no. 717 & no. 1172; French Village, col. M. S. B., no. 471, and Lake Kedji.

M. punctatum L.
Pictou, col. A. H. MacKay; Pirate's Cove; Baddeck; Margaree. Frequent in wet places in woods.

M. punctatum elatum Schp.
McNab's Is., Hfx., 1924, col. M. S. B., no. 470.

M. subglobosum B. & S.
Grand Lake, Hfx. Co., June 1924, col. M. S. B., no. 331; Lake Charlotte, 1930; Aspy Bay.

M. medium B. & S.
Barrasois and Ingonish, col. Nichols, no. 0956 & no. 705.

M. spinulosum B. & S.
Pirate's Cove, col. Macoun; Barrasois, col. Nichols, no. 0958.

M. Drummondii B. & S.
Pictou, col. A. H. MacKay.

M. hymenophylloides Huebn.
Pirate's Cove, col. Macoun; and Halfway Brook, C. B.

Cinclidium stygium Swartz.
Truro, in swamp, col. Macoun.

C. subrotundum Lindb.
Truro, 1883, col. Macoun; Oakfield, Hfx. Co., June 1924, col. M. S. B.

FONTINALACEAE. Aquatic mosses, floating in brooks.

Fontinalis antipyretica L.
Barrasois, no. 1207, and Ingonish, no. 682, col. Nichols; Pictou Co., col. A. H. MacKay.

F. dalecarlica B. & S.
Pirate's Cove and Halfway Brook, C. B., col. Macoun; Margaree.

F. seriata Lindb.
Halfway House, C. B., Aug. 1898, col. Macoun.

F. gigantea Sull. (Dixon makes this a var. of *F. antipyretica*).
Truro, Louisbourg and Margaree, July 1898, col. Macoun.

F. Delamarei Ren. & Card.
Aspy Bay, Aug. 1898, col. Macoun; also col. Nichols, in C. B.

F. biformis Sull.
Barrasois, col. Nichols, no. 214.

F. Cardoti Ren.

Barrasois, col. Nichols, no. 1281.

F. flaccida Ren. & Card.

Cape Smoky, col. Nichols, no. 728B.

F. Lescurii Sull.

Ingonish, col. Nichols, no. 700.

F. Novae-angliae Sull.

Yarmouth, 1883, and Halifax, col. Macoun; Barrasois, col. Nichols, no. 416.

F. Sullivantii Lindb.

Aspy Bay Mts., col. Nichols, no. 1012.

Dichelyma capillaceum B. & S.

Barrasois, col. Nichols, no. 1171; Windsor Jc., 1923, col. M. S. B., no. 469; Lake Kedji; Ellershouse.

NECKERACEAE. Tree-mosses.

Neckera pennata Hedw.

Pictou Co., col. A. H. MacKay; Whycocomagh. Common where there are shady woods, forming thick ruffs of a yellowish hue.

N. complanata Huebn.

Pictou Co., col. A. H. MacKay; Margaree, col. Macoun; George's River; Ellershouse; Lake Kedji. Rare.

Homalia Jamesii Schimp.

Big Intervale, Margaree, col. Macoun, July 1898; on rocks in ravine, Lochaber 1924, col. M. S. B., no. 390.

H. Macounii C. M. & Kindb.

Pirate's Cove, col. Macoun.

Anacamptodon splachnoides (Froelich) Brid.

Halifax, in knot-hole of elm, Oct. 28, 1924, col. M. S. B., no. 341; in Cape Breton, col. Nichols.[2] Rare.

LEUCODONTACEAE. Tree-mosses.

Leucodon brachypus Brid.

Pictou, col. A. H. MacKay; Lake Charlotte, col. M. S. B., no. 373, det. H. Dupret. Not rare, on trees in woods.

L. sciuroides (L.) Schwaeg.

Barrasois, no. 0994, and Ingonish, no. 917, col. Nichols; Lake Charlotte, col. M. S. B., no. 436.

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[2] Nichols. footnote 5. Bryol 19, 40, (1916).

LESKEACEAE.

Thelia hirtella (Hedw.) Sull.

Five Rivers, Queen's Co., July 1, 1924, col. M. S. B., no. 312, det. Dr. A. L. Andrews; Lake Kedji, Annap. Co.; Lake Annis, Yarm. Co.; North Mt., Annap. Co. New to N. S. Handsome dark green moss, clinging closely to trunk of trees.

Myurella julacea B. & S.

Cape Dauphin, col. Nichols, no. 599.

M. Careyana Sull.

Pirate's Cove, 1883, col. Macoun; also at Big Intervale, Margaree; Truro Park. On calcareous soil.

Leskia polycarpa Ehrh.

Musquodoboit, July 1924, col. M. S. B., no. 303, det. A. L. Andrews. On rough bark of willows. Annapolis; Middleton; Yarmouth.

L. obscura Hedw.

Lochaber, Guys. Co., July 1924, col. M. S. B., no. 301, det. Dr. A. L. Andrews.

L. nervosa Myrin (=*Leskeella* Loesk.)

Barrasois, col. Nichols, no. 0966; Blomidon, col. M. S. B., no. 387, det. H. Dupret.

Anomodon attenuatus Huebn.

Pictou Co., col. A. H. MacKay; Whycocomagh, col. Macoun. Frequent on trees and rocks.

A. rostratus (Hedw.) Schimp.

Pictou, col. A. H. MacKay; Ingonish, col. Nichols. Less frequent, but in large masses when found.

A. viticulosus Hook. & Tayl.

Big Intervale, Margaree, on rocks, col. Macoun.

A. tristis (Cesati) Sull.

Lake Charlotte, on tree, col. M. S. B., no. 368, det. H. Dupret. New to Canada, a very small fine moss, a Southern species.

A. Rugelii (C. Müll) Keissl. (=*A. apiculatus* B. & S.)

Lake Kedji, Aug. 1934, on dead tree, col. M. S. B., no. 524, ver. A. J. Grout; again at North Mt., Annap. Co. New to N. S.

Pterygynandrum filiforme Hedw.

Lake Kedji, on trees, col. M. S. B., no. 302, det. Dr. Andrews; Upper Sackville; Mt. Uniacke.

Pt. filiforme var. *decipiens* (W. & M.) Limpr.

Margaree and Halfway Brook, on rocks, col. Macoun.

Heterocladium dimorphum B. & S. (= *H. squarrosulum* Lindb.)
Barrasois to Aspy Bay, 10 collections, col. Nichols; White Rock, Kings Co., col. M S. B. Alpine and subalpine.

Thuidium abietinum. B & S.
Pirate's Cove, col. Macoun; Barrasois, col. Nichols, no. 0963; Falmouth.

Th. Blandovii B. & S.
Truro, col. Macoun; Aspy Bay, col. Nichols, no. 972; Dartmouth Barrens, col. M. S. B., no. 334.

Th. delicatulum Mitt.
Pictou Co., col. A. H. MacKay. A beautiful moss, common in shady woods all over N. S.

Th. recognitum Lindb.
Truro, col. Macoun; Barrasois, col. Nichols, no. 0961. Very like the last, but more rare.

Th. Philiberti Limpr.
Margaree, July 1898, col. Macoun; Lake Kedji, Annap. Co., col. M. S. B. Aug. 1934.

HYPNACEAE.

Climacium dendroides W. & M.
Barrasois, col. Nichols, no. 0990; Halifax, July 1922, col. M. S. B., no. 442. Rather common in damp grassy places.

Pylaisia polyantha B. & S.
Big Intervale, Margaree, col. Macoun, July 1898; Lake Charlotte, col. M. S. B., Aug. 1924, no. 452, det. H. Dupret. On trees.

P. Schimperi (= *P. intricata* B. & S.)
Pictou Co., col. A. H. MacKay. Macoun found it common at Baddeck and Margaree.

P. intricata (Hedw.) Ren. & Card.
Barrasois, col. Nichols, no. 1484; Upper Sackville, Hfx. Co., Oct. 1927, col. M. S. B., no. 438, det. H. Dupret.

P. pseudo-platygyrium Kindb.
Baddeck, 1898, col. Macoun.

Platygyrium repens (Brid.) B. & S.
Oakfield, col. M. S. B., no. 348, det. H. Dupret. Bedford; Port Mouton; Lake Charlotte.

Camptothecium nitens (Schreb.) Schimp.
Barrasois, col. Nichols, no. 1208.

Brachythecium albicans B. & S.
Barrasois, col. Nichols, no. 1486.

B. salebrosum B. & S.
Pictou, col. A. H. MacKay; Baddeck; Margaree. Common in woods, on boulders and on trees.

B. rutabulum B. & S.
Pictou Co., col. MacKay; Barrasois, col. Nichols, no. 09104.

B. rivulare B. & S.
Big Intervale, Margaree, col. Macoun; Fall River, Hfx. Co., col. M. S. B. Frequent in stony places near streams.

B. Starkei B. & S.
Barrasois, col. Nichols, no. 0999; Halifax, 1920, col. M. S. B., no. 351, det. H. Dupret.

B. glaciale B. & S.
Margaree, on trees in a swamp, col. Macoun.

B. reflexum B. & S.
Margaree, July 1898, col. Macoun; Bedford, May 1924, col. M. S. B., no. 409A, det. H. Dupret.

B. velutinum B. & S.
Blomidon, Aug. 1927, col. M. S. B., no. 404, det. H. Dupret.

B. populeum B. & S.
Pictou Co., col. MacKay; Margaree, col. Macoun. In damp woods on rocks.

B. plumosum B. & S.
Pirate's Cove and Halfway House, C. B., July 1898, col. Macoun; Margaree.

B. digastrum C. M. & Kindb.
Big Intervale, Margaree, on stones, col. Macoun.

B. flexicaule Ren. & Card.
Barrasois, col. Nichols, no. 1542.

B. oxycladon (Brid.) J. & S.
Mt. Uniacke, June 1927, col. M. S. B., no. 418, det. H. Dupret.

B. laetum Brid.
Pictou Co., col. MacKay; Truro, col. Macoun. On stones in woods.

Bryhnia Novae-angliae (Sul. & Lesq.) Grout.
Barrasois, col. Nichols, no. 09100; Oakfield, col. M. S. B., no. 322; Advocate; Blomidon.

B. graminicolor (Brid.) Grout.

Lake Charlotte, Aug. 1926, col. M. S. B., no. 300, det. H. Dupret. Very rare, a delicate moss, on rocks.

Eurhynchium praelongum Hedw.

Barrasois, col. Nichols, no. 09173.

E. myosuroides Schp.

On trees, Nova Scotia, col. James; Yarmouth, col. Macoun; Papermill Lake, Hfx. Co., Sept. 1935, col. M. S. B., no. 544.

E. stoloniferum (Hook.) J. & S.

Port Mouton, July 1924, col. M. S. B., no. 377, det. H. Dupret; Sandy Cove, Digby Co.; Lake Annis, Yar. Co.

E. strigosum (Hoffm,) B. & S.

Pictou Co., col. MacKay; Barrasois, col. Nichols, no. 09102; Lake Kedji; Yarmouth Co.

E. hians Hedw.

Pirate's Cove, on earth, col. Macoun.

E. rusciforme Milde.

Pirate's Cove and Margaree, col. Macoun; Margaretville. Not rare on stones in brooks.

E. rusciforme var. *complanatum* Schultze.

Barrasois, col. Nichols, no. 1539.

Sematophyllum recurvans (Mx.) E. G. Britton.

Barrasois, col. Nichols, no. 265; Port Mouton, 1924, col. M. S. B., no. 408; Bedford; Dartmouth Lakes; Lake Kedji. Not rare.

S. Carolinianum (C.M.) C. G. Britton.

Fall River, Hfx. Co., 1924, col. M. S. B., no. 410, det. H. Dupret.

S. tenuirostris (B. & S.) E. G. Britton.

Barrasois, col. Nichols, no. 266.

S. delicatulum E. G. B. (= *Rhaphidostegium laxepatulum*)

Margaree, on old logs, col. Macoun.

Plagiothecium elegans Sull.

Pictou, col. MacKay; Barrasois, col. Nichols, no. 1339.

P. Mühlerianum Schp.

Barrasois, col. Nichols, no. 1308; Halifax, Sept. 1920, col. M. S. B., no. 350, det. H. Dupret.

P. pulchellum B. & S.

Barrasois, col. Nichols, no. 1336.

P. denticulatum B. & S.
Pictou, col. MacKay; Pirate's Cove, col. Macoun. The most common species, in damp woods everywhere.

P. sylvaticum B. & S.
Barrasois, col. Nichols, no. 09167; Hfx. Dingle, Sept. 1920, col. M. S. B., no. 553, det. H. Dupret.

P. Roeseanum Hampe. (=*P. Sullivantiae* Schp.)
Truro, col. Macoun. On earth and on rock.

P. Mühlenbeckii B. & S. (=*P. striatellum* Lindb.)
Pictou, col. MacKay; Margaree and Halfway Brook, col. Macoun.

P. turfaceum Lind.
Pictou Co., col. MacKay; Barrasois, no. 1314 & Ingonish, no. 1716, col. Nichols.

P. deplanatum Schp.
Truro, col. Macoun.

P. aciculare-pungens (C. M.) Kindb.
Margaree ravine, col. Macoun; Halifax, col. J. Moser.

Amblystegium Sprucei B. & S.
Ingonish, col. Nichols, no. 1714; Peggy's Cove, Oct. 1931, col. M. S. B., no. 492.

A. confervoides B. & S.
Cape Dauphin, col. Nichols, no. 594; George's River, col. M. S. B.; Peggy's Cove, no. 304, det. Andrews.

A. serpens (L.) B. & S.
Halifax Public Gardens, on coral rock, col. M. S. B., no. 384, det. H. Dupret.

A. varium (Hedw.) Lindb.
Newport, N. S., col. M. S. B., no. 500, det. H. Dupret; Pictou, col. MacKay, (as *A. porphyrhizon*); Mt. Uniacke.

A. irriguum B. & S.
Blomidon, in ravine, Aug. 1927, col. M. S. B., no. 388, det. H. Dupret.

A. Kochii B. & S.
Public Gardens, Hfx., on limestone rock, no. 384A, col. M. S. B., det. A. G. Grout.

A. fluviatile B. & S.
Cape Breton, on stones in brooks, col. Macoun.

A. adnatum (Hedw.) J. & S.
Oakfield, on tree, 1924, col. M. S. B., no. 325, det. H. Dupret.

A. filicinum De Not.
Truro, by springs, col. Macoun; Aspy Bay, col. Nichols, no. 969.

A. subtilis (Hedw.) Loeske.
Barrasois, col. Nichols, no. 091.

A. *orthocladon* (Beauv.) L. & J.
Pictou Co., col. MacKay.

Sciaromium Lescurii (Sull.) Broth.
Maitland Falls, Annap. Co., Aug. 1934; Ellershouse, July 1935, col. M. S. B., det. A. G. Grout. New to N. S.

CAMPYLIUM.

Hypnum riparium (L.) Braithw.
Ingonish, col. Nichols, no. 683; Hfx. Public Gardens and Dartmouth Lakes, col. M. S. B., no. 509.

H. vacillans Sull.
Ingonish, col. Nichols, no. 888.

H. polygamum Schp.
Barrasois, col. Nichols, no. 540; Lochaber, Guys. Co., col. M. S. B., no. 399, det. H. Dupret.

H. stellatum Schreb.
Barrasois, col. Nichols, no. 672; also Ingonish and Aspy Bay; Elderbank; Peggy's Cove. Not rare.

H. chrysophyllum Brid.
Pictou Co., col. A. H. MacKay; Barrasois, col. Nichols, no. 09175; Aspy Bay; St. Croix.

H. chrys. var. *brevifolium* Grout.
Mt. Uniacke, June 1927, col. M. S. B., no. 285, det. H. Dupret. On trees.

H. hispidulum Brid.
Truro, col. Macoun; Barrasois, col. Nichols, no. 09108. This and the four preceding, on calcareous soil.

H. sinuolatum Kindb.
Big Intervale, Margaree, July 1898, col. Macoun.

DREPANOCLADUS (C.M.) Roth = HARPIDIUM

Hypnum aduncum Hedw. non Linn.
Various parts of N. S. Harpidium Section are all swamp mosses, and very variable, found in many forms, and variously named by different authors,

H. ad. var. *aquaticum* Sanio.
Lake Kedji, col. M. S. B., no. 532, det. Grout.

H. uncinatum Hedw. (=H. *aduncum* Linn.)
Common all over the Province. Pictou, col. MacKay; Truro, col. Macoun; Barrasois, no. 099, col. Nichols. Dr. Nichols also lists the varieties following, all in Cape Breton:—

var. *plumosus* Schp.—no. 09122.
var. *gracilascens* B. & S.—no. 09126.
var. *gracillimus* Berg.—no. 09127.
var. *alpinus* Ren.—no. 1200.
var. *plumulosum* Schp.—Port Mouton, col. M. S. B., no. 422.

H. Sendtneri Schp.
Aspy Bay, Aug. 1898, col. Macoun. On stones in brook.

H. pseudo-lycopodioides Kindb.
Margaree, col. Macoun. On stones in woods.

H. Moseri Kindb.
Margaree, col. Macoun.

H. fluitans L.
Sable Is. and Halifax, in peat bogs, col. Macoun; Barrasois, col. Nichols, no. 503.

H. fluitans var. *gracilis* Boul.
Dartmouth Barrens, col. M. S. B., no. 431, det. L. S. Cheney.

H. fluitans var. *Jeanbernati* Ren.
Clam Harb., col. M. S. B., no. 380, det. L. S. Cheney.

H. fluitans var. *falcifolius forma viridis* Boul.
Dartmouth Barrens, Sept. 1923, col. M. S. B., no. 427, det. L. S. Cheney.

H. exannulatum Guemb.
Sable Is., col. Macoun; Barrasois, col. Nichols, no. 88; Ingonish Mts., no. 795.

H. exan. var. *purpurascens* Schp.
Ingonish Mts., col. Nichols, no. 1659.

H. revolvens De Not.
Ingonish Mts., col. Nichols, no. 794.

H. serratus Milde.
Barrasois, no. 1911, col. Nichols.

H. *submersus* Schp.
Ingonish, No. 822, col. Nichols.

DREPANIUM.

H. cupressiforme L.

Pirate's Cove and Truro, col. Macoun; Barrasois, col. Nichols, no. 097; Halifax. Very common, on trees and on rocks, all over the Province, and very variable.

H. imponens Hedw.

Pictou Co., col. MacKay; Margaree, col. Macoun. Quite common, and fruiting freely, on rocks in woods.

H. reptilis Michx.

Pictou Co., col. MacKay; Barrasois, col. Nichols. Everywhere in Bedford and around Halifax. Also common, on trees, old stumps, on flat rocks in woods; smaller than *H. impones*, and forming a thinner mat.

H. curvifolium Hedw.

Truro, col. Macoun, 1898; Pictou, 1907,[3] col. C. B. Robinson; Musquodoboit, col. M. S. B., no. 460. Larger than *H. imponens*, and uncommon.

H. callichroum Brid.

Shelburne, col. James; Ingonish Mts., col. Nichols, no. 1664; Musquodoboit, 1924, col. M. S. B., no. 359A, det. L. S. Cheney.

H. fertile Sendt.

Baddeck and Margaree, col. Macoun; Dingle, Hfx., col. M. S. B., no. 326, det. H. Dupret.

H. canariense Mitt. (=*H. Waghornei* Kindb.)

Baddeck, July 1898, col. Macoun.

H. pallescens Hedw. (=*H. Jamesii* Sull.)

Barrasois, col. Nichols, no. 09113; North Mt., Blomidon, 1928, col. M. S. B., det. L. S. Cheney.

H. molluscum Hedw.

Pictou Co., col. MacKay.

H. molluscoides Kindb.

Baddeck, July 1898, col. Macoun. On old logs.

H. fastigiatum Brid.

Halifax, June 1883, col. Macoun. On trees.

H. Canadensis Kindb.

McNab's Is., Hfx., col. Macoun. On stones.

H. crista-castrensis L.

Pictou, col. MacKay; Truro, col. Macoun; Barrasois, col. Nichols, no. 09118. Not uncommon in woods, a very distinctive and handsome moss, the "knight's plume."

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[3] Nichols, footnote 6. Bryol **19**, 40, (1916).

H. Haldanianum Grev.
Pictou Co., col. MacKay. Truro, col. Macoun; Barrasois, col. Nichols, no. 1391. Common everywhere.

H. Patientiae Lindb.
Barrasois, col. Nichols, no. 0910; Ingonish Mts.

H. Patient. var. *elatus* Schp.
Fall River, Hfx., 1924, col. M. S. B., no. 319, det. A. L. Andrews.

H. pratense Koch.
Ingonish, col. Nichols, no. 13; Barrasois, no. 0930.

LIMNOBIUM. Mosses on wet rocks in brooks, etc.

H. palustre Huds.
Barrasois, col. Nichols, no. 1133.

H. dilatatum Wils.
Cape Dauphin, col. Nichols, no. 601.

H. arcticum Sommerf. (= *H. Smithii* Sw.)
Barrasois, col. Nichols, no. 1448.

H. eugyrium var. *Mackayi* Schp.
Pictou Co., col. MacKay; Margaree and Pirate's Cove, col. Macoun. Common in beds of streams.

H. alpestre Sw.
Barrasois, col. Nichols, no. 1496.

H. ochraceum Turn.
Pictou Co., col. MacKay; Truro, col. Macoun. He found it "abundant in brooks in Cape Breton."

H. scorpioides L.
Ingonish Mts., col. Nichols, no. 792.

CALLIERGON.

H. stramineum Dicks.
Baddeck, 1898, col. Macoun; Herring Cove, Hfx., col. M. S. B., no. 332; Musquodoboit. In bogs.

H. cordifolium Hedw.
Pictou, col. MacKay; Baddeck, 1898, col. Macoun. Frequent, in boggy places.

H. giganteum Schp.
French River and Aspy Bay, col. Nichols, no. 1815.

H. cuspidatum L.

Louisbourg, Aug. 1898, col. Macoun; Mt. Uniacke, col. M. S. B., no. 383, det. H. Dupret.

H. Schreberi Willd.

Pictou Co., col. MacKay; Barrasois, col. Nichols, no. 0989. Very common, grows in profusion everywhere, but rarely fruits.

Hylocomium splendens B. & S.

Pictou, col. MacKay; Barrasois, col. Nichols, no. 0987a. Common everywhere, and one of the most beautiful of mosses; rarely found fruiting.

H. umbratum B. & S.

Pictou Co., col. MacKay; Margaree, Baddeck, col. Macoun. Subalpine plant, rather rare.

H. brevirostre B. & S.

Pictou Co., col. MacKay; Hfx. Co., col. J. Moser; Grand Narrows, col. Macoun. Robust, in large cushions; subalpine, but more frequent than the last.

H. loreum B. & S.

Aspy Bay, col. MacKay; Pirate's Cove, col. Macoun. Subalpine, beautiful, in deep ravines.

H. squarrosum B. & S.

Pictou Co., col. MacKay; Margaree, 1898, col. Macoun. Frequent in damp grassy spots.

H. calvescens Wils.

Truro, col. Macoun, "fruiting, on rocks."

H. triquetrum B. & S.

Pictou Co., col. MacKay; Barrasois, col. Nichols, no. 94. Frequent, a large coarse moss; has been used for packing china.

PRESIDENTIAL ADDRESS.

Harry Piers.

(Read October 9, 1935).

In my first presidential address at the opening of the seventy-fourth session of the Nova Scotian Institute of Science, I would like to express my deep appreciation of the unexpected honour done me, one year ago, in electing me to the presidency of one of the oldest scientific societies in Canada. I feel that you do not need any assurance that the Institute has ever had my keenest interest as well as my loyal, whole-hearted service.

Glances at the Past.

Being now the senior active member of the society, the occasion naturally brings vividly to my mind many thoughts of the past, some of which may perhaps be pardonably noted, personal though many of them may be.

The first meeting I attended was in November, 1887, when I was a lad of seventeen years, a student at the Halifax Academy, but also studying daily, under the aged Dr. David Honeyman, in the Provincial Museum. The meetings were then being held in the drafty draughting-room of the Provincial Engineer's office on the top floor of the Province Building. Dr. John Somers, the seventh president, a long-moustached, grey-headed, kindly ex-army-surgeon of the American Civil War, and a keen but perhaps not very precise fungologist and general botanist, was in the chair, and the paper was one by my preceptor, Dr. Honeyman, on "Glacial Geology in Nova Scotia," in which he referred to some slight assistance I had given him in the way of material for his then favourite theme. The discussion in those days was always quite formal, and all who joined in it arose to address the chair.

Then my association with the Institute goes back forty-eight years or three-fifths of the period of its existence; and since then attendance at meetings has never once been missed except through illness or some such unavoidable cause.

The society was then composed of men, every one of whom, with the exception of Mr. F. W. W. Doane, has since passed away. There were 34 ordinary members and 5 associates, or a total of 39, not counting corresponding-members. The equivalent numbers today are 65 and 13, a total of 78, or exactly twice the number of forty-eight years ago. In the intervening years the population of the city has increased from about 37,500 to about 60,000.

Among the more prominent men attending the meetings in those days were: the aged, yet sprightly, Dr. Honeyman, a doughty opponent of some of Sir William Dawson's views, and the rather young and dry-humoured Edwin Gilpin, geologists; grave-faced and experienced Dr. Lawson and kindly Dr. Somers, botanists; Andrew Downs, the veteran ornithologist, formerly the proprietor of the first zoological garden in America, and one-time correspondent of Audubon; Arthur P. Silver, a young but keen lepidopterist and sportsman, later author of "Farm, Cottage, Camp and Canoe in Maritime Canada"; the also young, auburn-haired, keen-eyed, vivacious and quick-witted Dr. J. Gordon MacGregor, physicist; light-hearted, companionable Augustus Allison, meteorologist; the ever black-haired, thick-browed, quiet, but kindly Maynard Bowman, analyst; big, open-hearted Martin Murphy, an Irish engineer of wide experience and marked ability; as well as the venerable William Gossip, who knew all about printing, the very tall and stately, and unusually long-bearded W. C. Silver, the small, quiet John J. Fox, and the sober-faced Alexander McKay, supervisor of schools,—the three latter of whom, particularly the last, were generally interested in science and natural history. Among occasional attendants and lecturers from out-of-town, were the rather austere-featured Rev. Dr. George Patterson, archaeologist and historian from Pictou, and the stalwart Rev. Dr. John Ambrose whose long residence in coastal parishes caused him to be an authority on our marine food-fishes. Dr. J. B. Gilpin and J. M. Jones ("Bug Jones" as his many friends called him), both of whom had contributed very largely to the Transactions, had gone into retirement; and A. H. MacKay did not arrive in Halifax till a couple of years later. Of all these gentlemen, only Downs, Gossip, Jones and J. B. Gilpin had been original members.

They nearly all seemed very old to my boyish eyes, yet their average age was about fifty-five, ranging from twenty-four to seventy-eight. All but three (E. Gilpin, F. W. W. Doane, and A. P. Silver) wore beards or at least side-whiskers; and all were dignified, courteous and kindly gentlemen of the old school, and were ever ready to assist a youngster. You may, however, be assured that the awed high-school lad felt decidedly insignificant in such grown-up and experienced company, and always silently occupied a back seat, although listening intently to all that was said.

Early in 1888, on the day after my eighteenth birthday, I was permitted to read my first paper, one on the occurrence of some rare fishes and on fish development. In November of the same year, during the presidency of Dr. MacGregor, my true and ever-lamented friend and the society's most energetic president, I was elected a member, and at the same meeting was appointed assistant-librarian, which position was held till 1890. In November, 1891, I entered the council, and three years later became recording-secretary, and, as you know, served as such for forty years.

In contrast with conditions existing at present, when efficient and painstaking officers divide the work, for many years various duties fell upon the recording-secretary. Up till 1903 he billed for, collected and gave receipts for all fees, which were then transferred to the treasurer for inclusion in his accounts. Then from 1901 to 1908 he was editor of the Proceedings and Transactions; from 1902 was librarian; and furthermore, until recent years, almost all routine correspondence was carried on by him. So that, perhaps, in his day he took, as far as he was able, his full share of the work, and was glad to do it.

Hoping that the foregoing reminiscent remarks from one of the society's "old-timers" have not been wearisome, we will now pass to the concerns of the immediate past.

Review of the Past Year.

In reviewing the work and events connected with the Institute during the past year, I must first refer with much sorrow to the passing of Daniel Alexander Murray, Ph.D., late professor of applied mathematics at McGill University, Montreal. He was born in Colchester Co., N.S., and educated at Dalhousie and John Hopkins Universities, and in Berlin and Paris. He then devoted himself to teaching in his native province, first in the Dartmouth schools, then as principal of Shelburne Academy. Later he became tutor of mathematics at Dalhousie University, associate-professor of the same subject in the University of New York, instructor in Cornell University, and then a full professor at Dalhousie. Since 1907 he had been on the staff of McGill. He was a member of various notable learned societies, and published well-known treatises on "Differential Equations," "Integral Calculus," "Plane Trigonometry" and "Spherical Trigonometry." He joined our Institute in December, 1903, and had been associated with it up to the time of his death. I trust that a fuller obituary, recording his eminent services in his chosen field, will appear in the Proceedings.

The appointment of our fellow member, Dr. E. W. H. Cruickshank, the distinguished professor of physiology at Dalhousie University, to a highly important chair at Edinburgh, is a matter which calls for our heartiest congratulations; but mingled with our pleasure at the well-deserved honour done him, is a sense of deep regret at the loss of one of our most prominent members. We wish him and his talented wife every success, and know that he will not forget the tie which has bound him for nearly seven years with a small but earnestly working society in New Scotland, nor she her prominent association with musical life here.

This approaching departure of Dr. Cruickshank recalls the appointment, thirty-four years ago, of one of our former presidents, the late Dr. J. Gordon MacGregor, to the chair of natural philosophy in the same great university, then lately occupied by the eminent Tait; on which occasion a dinner was tendered to the man who was no doubt the most energetic and inspiring president we have ever had.

During the past session eight meetings were held, including the annual business one, from October to May, at which the average attendance at the ordinary gatherings was twenty-three as compared with twenty in the previous year, while at the popular lectures the attendance was about one hundred, and fifty.

At the seven ordinary meetings twenty-three papers were presented, being an average of about three at each meeting. Two of the meetings were of a popular nature; one of them being devoted to an address by Mr. T. E. Kloss on the Chemistry of Paper-making, and the other to addresses by Dr. Henderson on Simon Newcomb, by Dr. Bean on the Historical Development and Present Programme of the Institute, and by Capt. Mitchell on Life-saving Appliances on Merchant Ships. There was also one demonstration by Mr. J. R. Dacey on Chemiluminiscence. To all who thus contributed to the success of the session, we tender sincere thanks.

The papers may be thus classified: physics, 2; mineralogy, 1; geology, 3; meteorology, 1; botany, 1; chemistry, 1; biochemistry, 1; zoology, 7 (made up of: crustaceans, 1; insects, 1; and fishes, 5); useful arts, 4 (made up of: public health or medicine, 1; life-saving, 1; chemical technology, 1; and food-treatment, 1); and biography and history, 2. This indicates that the programme has been of a highly diversified character, with papers on zoology (7), the useful arts (4), geology (3), and physics (2) prevailing.

While speaking of our meetings, I voice the feelings of all in expressing thanks to the staff of the Medical Science Building for the long-accorded privilege of using the biochemistry lecture-room for our monthly gatherings, and also for the frequent use of a projection-lantern.

In June last there was published part 3 of volume 18 of the Proceedings, for the session 1933-4, consisting of 79 pages, containing 9 papers printed in full, some 32 illustration maps, figures and graphs, as well as abstracts of 12 other papers. Comparing this with previous parts of the same volume, we find that part 1 (1930-1) contained but 2 full papers, 11 abstracts, and 21 pages; part 2 (1931-2), 5 papers, 7 abstracts, and 51 pages; and part 3 (1932-3), 9 papers, 7 abstracts, and 149 pages. This is an average of 6¼ papers, 9¼ abstracts, and 75 pages in each of the four parts.

Progress in printing the Proceedings for the past session (vol. 19, part 1) will be reported upon by the capable editor, Dr. King. As the part will be a large one of about 150 pages, containing seven papers, including an extensive and important one on our marine fishes, its cost will make a considerable inroad on our never-too-large treasury.

As you know, the Institute has undertaken, under the able and freely given direction of our energetic corresponding-secretary, Dr. Hess, the compilation of a much needed catalogue of all scientific journals which are available in the various libraries of the Maritime Provinces, chief among which is that of our own Institute in the Provincial Science Library. This laborious work, which when issued will be of great assistance to research-students, is now about completed, and as the expense of publication will be considerable, we are pleased to know that greatly appreciated financial assistance has been granted by the National Research Council of Canada.

We should not neglect to mention that at the last annual meeting a lady, Dr. Margaret R. Butler, was for the first time elected a member of the Council, and we may foresee the time when a lady will preside over the destinies of the society. In this connection it will be recalled that in December, 1900, the first lady, Miss A. Louise Jaggar, then at Smith Cove, N.S., but later of Cambridge, Mass., was admitted an associate member, and the innovation was hailed with enthusiasm. We now have three ladies among our ordinary and associate members, and of recent years several important papers have been their welcome contribution to our Proceedings.

During the past summer a notable event in the history of science, as it affects this province, was the unveiling of an inscribed tablet erected by the Historic Sites and Monuments

Board of Canada, at the little village of Wallace Bridge, Cumberland Co., to commemorate the birth and career of Simon Newcomb, Nova Scotia's world-famous astronomer. This well-deserved tribute to a great man was the result of the efforts of our vice-president, Dr. G. H. Henderson, and the drafting of a suitable inscription had been deputed to a committee of this Institute of which he was the head. The president and members were cordially invited by Prof. D. C. Harvey to be present, and a card was sent to all members urging them to be present, but I fear that only your president and vice-president were able to take advantage of the kind invitation. The ceremony took place before a large and distinguished assembly, on 30th August, 1935, the principal address being given by Dr. Henderson, while others who spoke were His Honor Lieut.-Governor Covert, Mr. Norman Armour, the U. S. Ambassador to Canada, Dr. Raymond C. Archibald, Dr. Newcomb's daughter, who unveiled the tablet, and others.

The Approaching 75th Anniversary of the Institute's Organization.

Now, to look somewhat into the future, it is probably not too soon to bring to mind the fact that this Institute, which was organized on 31st December, 1862, will begin its Seventy-fifth Annual Session in the autumn of 1936. That time might very appropriately be the occasion of some sort of commemorative meeting such as was held on the completion of a half-century of activity, on 20th January, 1913. Three-quarters of a century of uninterrupted and productive work in the field of science in this province is surely worthy of more then mere passing notice. I am sorry to say that most of us will not be here when the more note-worthy centenary arrives, and therefore we would now like to take befitting notice of such an outstanding milestone as the seventy-fifth when it is passed on the long road leading into the as yet unexplored region of scientific endeavour in Nova Scotia.

Field-meetings.

We recall that very many years ago the Institute held occasional field-meetings, but they were usually not well attended, and have not since been revived. It has occurred to me that possibly at some future time an experimental effort might be made to resuscitate what should be a popular and pleasant way of increasing general interest in the geology and natural history of our locality. Perhaps this might be tried through a meeting under the guidance of Prof. Douglas, at which prominent features in the geological structure underlying Halifax might be demonstrated in an attractive and practical manner. In this connection it may be noted that our sister society, the Nova Scotia Historical Society, has for a number of years met with success in holding summer excursions to points of historic interest in and about Halifax. Such excursions, both historical and scientific, are still quite popular in England. Our trouble would be that most of our members are then away on their vacations.

In conclusion I desire to thank the officers, particularly the Treasurer, and the Corresponding and Recording Secretaries, for their freely-given services during the year, and the members of the Council for the notably large attendance at their meetings. Our gratitude is also due to the Editor, Dr. King, and the Editorial Board, nor should we forget the services of our two representatives on the Provincial Science Library Commission, and of our delegate to the meeting of the Royal Society of Canada.

PROCEEDINGS OF MEETINGS.

SESSION OF 1935-36.

(All meetings were held in the Medical Science Building, Halifax.)

74th Annual Business Meeting, Oct. 9th, 1935. The annual address of the President was read by Harry Piers, Esq.

The Treasurer's Report showed the financial situation to be as follows: Receipts during the year, $1385.35; expenditures, $422.08; leaving a balance in the savings bank of $963.27. The reserve fund contains $243.48 in Dominion Savings, and $500.00 in a Dominion of Canada Bond. The Endowment fund consists of $1000.00 in Telephone Bonds, and $1500.00 in Dominion of Canada Bonds.

The Corresponding Secretary reported that during the year 266 back copies of the "Proceedings" had been sent out. His work of preparing a Catalogue of Scientific Periodicals in the Libraries of the Maritime Provinces was showing satisfactory progress, aided by a grant of $100.00 from the Institute and $300.00 from the National Research Council of Canada. It was anticipated that the catalogue would be published during the current session.

The Librarian reported that the Provincial Government grant of $500.00 had been made as usual.

The Editor reported that one number of the "Proceedings" had appeared during the past summer and another was in press.

Officers elected for 1935-36. *President*, Harry Piers, Esq.; *vice-presidents*, Prof. George H. Henderson, Ph.D., Prof. Harold S. King, Ph.D.; *treasurer*, Donald J. Matheson, B.Sc.; *corresponding secretary*, Prof. Ernest Hess, Ph. D.; *recording secretary*, Prof. F. Ronald Hayes, Ph.D.; *librarian*, Harry Piers, Esq.; *members of the Council*, Capt. W. F. Mitchell, Prof. Donald Mainland, D.Sc., Prof. C. C. Coffin, Ph.D., Prof. R. J. Bean, M.S., Margaret R. Butler, Ph.D., Prof. G. V. Douglas, M.Sc., D. LeB. Cooper, Ph.D.; *members nominated by the Institute to the Provincial Science Library*

Commission, Prof. G. H. Henderson, Ph.D., Prof. Ernest Hess, Ph.D.

1*st Ordinary Meeting*, Nov. 4th, 1935. New members announced (elected by Council Oct. 28); Ordinary member, John M. Morton; associate members, George R. Smith, Arthur Kelsall.

Obituary:—The Institute learns with deep regret of the death of Captain Walter Frederick Mitchell on October 24th. Captain Mitchell was elected a member of the Institute in 1927 and was entering upon his fifth term as a Councillor. Sixty-three years of age, he had had an eventful career on the sea and at the time of his death was Superintendent of Pilots for Halifax and Acting Examiner for Masters and Mates. In three popular lectures he shared his store of experience with us. In the Council meetings his unique personality will be greatly missed. Though not a scientist himself, he had a fine appreciation of pure science.

Papers: 1—The marine fishes of Nova Scotia, by V. D. Vladykov and R.A. McKenzie. 2—The sterilization of canned fisheries products, by D. Cooper. 3—*Schizoporella unicornis*, a Bryozoan new to Canada, by D. Pelluet and F. R. Hayes.

2*nd Ordinary Meeting*, Dec. 9th, 1935. New student members announced (elected by Council Nov. 25); Dennis W. Watson, N. E. Brown. Papers: 1—The deterioration of "marinated herring," by Ernest Hess and Dennis W. Watson. 2—Studies on explosive antimony; the magnetic susceptibility, by C. C. Coffin. 3—The behaviour of bone and cartilage of young guinea-pigs under the influence of anterior pituitary extract of cattle, by Ruth Silberberg.

3*rd Ordinary Meeting*, Jan. 13th, 1936. New members announced (elected by Council Dec. 30); Ordinary members, Ruth Silberberg, Martin Silberberg, Arthur Labrie; associate member, J. Fred. Hockey. Papers: 1—Behaviour of thyroid under the influence of two growth stimuli simultaneously applied, by Martin Silberberg. 2—Some bacteriological aspects of fish handling, by N. E. Gibbons. 3—Development of the fruit bud of the apple (McIntosh Red) in Nova Scotia, by Vera Facey.

4th Ordinary Meeting, Feb. 10th, 1936. Papers: 1—The detection and measurement of incipient spoilage in fish muscle, by S. A. Beatty. 2—Three rare fish from Passamaquoddy Bay, N.B., by R. H. M'Gonigle and M. W. Smith. 3—Determination of selenium in gold concentrates, by Harold S. King and Evelyn O. Nickerson.

5th Ordinary Meeting, Mar. 9th, 1936. Papers: 1—The mosses of Nova Scotia, by Margaret S. Brown. 2—On the heat capacity of silver, nickel, zinc, cadmium, and lead from -80° to 120° C., by Arthur J. C. Wilson. 3—Smoke-curing of fresh fillets, by E. P. Linton and D. LeB. Cooper.

6th Ordinary Meeting, Apr. 8th, 1936. New members announced (elected by Council Mar. 30); Ordinary member, Margaret S. Brown; student member, Ross Homans. Papers: 1—Observations on the development of storage scab of apples, by J. Fred. Hockey. 2—The metabolism of developing salmon eggs; a quantitative study of the total fat content, by D. M. Ross. 3—Pleochroic haloes of the thorium family, by D. P. Crawford.

7th Ordinary Meeting, May 4th, 1936. Papers: 1—The separation and characterization of the proteins of egg white, by E. Gordon Young. 2—Further studies on the breakdown of complex molecules, by J. R. Dacey and N. A. D. Parlee.

F. RONALD HAYES.
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

THE STERILIZATION OF CANNED FISHERIES PRODUCTS. D. LeB. Cooper, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Nov. 4, 1935). The rate of heat penetration into cans of solidly packed fish and fish pastes was measured and shown to be independent of the nature of the fish within the limits of accuracy required. The results were applied to an equation expressing the rate of heat penetration into cans, and found to agree with the theory.

THE DETERIORATION OF "MARINATED HERRING", by Ernest Hess and Dennis W. Watson, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Dec. 9, 1935). Marinated herring which are preserved by curing in vinegar, salt and spices are consumed without cooking. As the concentration of the curing agents used is limited by their palatability, and as no heat is applied at any time, the product is semi-perishable, unless stored at ice-box temperatures. At room temperature deterioration begins after about one month's storage in the form of a softening and loosening of the skin, followed by softening and disintegration of the flesh without noticeable spoilage odours. Experiments have shown that neither micro-organisms nor acid hydrolysis play an important part in this break-down of the fish flesh. The most important agent was shown to be enzymatic hydrolysis, by means of studies on bacteria-free filtrates of fish muscle extracts and on samples of marinated herring preserved under toluol. The enzyme action may be decreased by using higher salt concentrations in curing, or by using salt herring instead of fresh herring as raw material. Further means of inhibiting enzymatic hydrolysis at room temperature are under consideration.

STUDIES ON EXPLOSIVE ANTIMONY. THE MAGNETIC SUSCEPTIBILITY. C. C. Coffin, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Dec. 9, 1935). Explosive antimony is only half as diamagnetic as ordinary crystalline antimony and is therefore in all probability a true super-cooled liquid.

THE BEHAVIOR OF BONE AND CARTILAGE OF YOUNG GUINEA-PIGS UNDER THE INFLUENCE OF ANTERIOR PITUITARY EXTRACT OF CATTLE. Ruth Silberberg, Dept. of Pathology, Dalhousie Univ., Halifax, N. S. (Read Dec. 9, 1935). Young guinea-pigs were injected with one to one and a half cc. of anterior pituitary extract of cattle daily for periods from 4 days to 1 month. The conditions of bone and cartilage were examined. In another series of animals the bones of one lower leg were fractured and the growth phenomena at the stumps were observed over periods from 4 days to 3 weeks. As a result of both series a distinct stimulation of the growth of cartilage was noted with hypertrophy and hyperplasia of the different cells, followed by an accelerated calcification of the newly grown cartilage, which may cause a premature closure of the epiphyseal line and a faster healing process of the fracture.

BEHAVIOUR OF THYROID UNDER THE INFLUENCE OF TWO GROWTH STIMULI SIMULTANEOUSLY APPLIED. Martin Silberberg, Dept. of Pathology, Dalhousie Univ., Halifax, N. S. (Read Jan. 13, 1936). The experiments were carried out in young guinea-pigs in order to analyze the behaviour of the thyroid gland under the influence of two stimuli simultaneously applied. Potassium iodide and anterior pituitary extract of cattle were used as exogenous growth-promoting substances, while the development of compensatory hypertrophy is to be considered as due to an endogenous growth stimulus. 1. By combined administration of potassium iodide and anterior pituitary extract each substance exerts its specific effects on the thyroid, but usually no real intensification takes place. 2. Correspondingly, under varying conditions the influence of injections of the extract of cattle anterior pituitary on the growing thyroid (compensatory hypertrophy) is established, as follows: The development of this compensatory hypertrophy may interfere with the growth-promoting effects of the extract, while the influence of the extract is diminished compared with the behaviour of the normal gland under the influence of the extract. Therefore as far as growth phenomena are concerned one may conclude that: The influence of two growth stimulating energies simultaneously applied can be explained in accordance with the rules of interference.

SOME BACTERIOLOGICAL ASPECTS OF FISH HANDLING. N. E. Gibbons, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Jan. 13, 1936). Rise in bacterial numbers in fish muscle juice follows the rise in volatile base Nitrogen. Bacterial counts on peritonea of iced fish show that thorough washing has little effect on time of storage. Penetration of gut in non-feeding fish is slow; in feeding fish enzymatic action causes "belly burn" before bacterial penetration.

DEVELOPMENT OF THE FRUIT BUD OF THE APPLE (MCINTOSH RED) IN NOVA SCOTIA. Vera Facey, Dept. of Botany, Dalhousie Univ., Halifax N. S. (Read Jan. 13, 1936). The differentiation of the fruit bearing tissue is traced from the first appearance of primordia on June 8 to the mature flower the following May. In other reports a differentiated flower growing tip was not identified so early, but the development from then until the Autumn parallels the development of the apple as reported for the northern United States and England. For Nova Scotia, development is reported as continuous throughout the winter, although previous accounts from other places do not record any development between late Autumn and early Spring. The winter buds resist infiltration. To overcome this difficulty a new technique is described by which, except for the few minutes when solutions were changed, the buds were kept in a vacuum from the time they were first put in alcohol, till the infiltration with paraffin was completed.

THE DETECTION AND MEASUREMENT OF INCIPIENT SPOILAGE IN FISH MUSCLE. S. A. Beatty, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Feb. 10, 1936). A method for the determination of trimethylamine in cod and haddock muscle has been devised. In cod and haddock stored at temperatures between 0°C and 20°C the development of trimethylamine parallels the rise in bacterial population. Putrefactive odors are always detected at approximately the same trimethylamine level. Since the rise in trimethylamine is significant before any putrefactive odor can be detected, the trimethylamine value is not only a qualitative test more sensitive than ordinary organoleptic tests, but also a quantitative measure of spoilage.

THE DETERMINATION OF SELENIUM IN GOLD CONCENTRATES. Harold S. King and Evelyn O. Nickerson, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Feb. 10, 1936). A study has been made of the bromide method of estimating selenium. About 95% of selenium may be recovered by this method. The presence of gold, tellurium or arsenic does not interfere. The concentrates from Waverley contained 0.01%, from Goldenville, 0.02%, from Brookfield, 0.04% and from Montague, 0.06% Se.

ON THE HEAT CAPACITY OF SILVER, NICKEL, ZINC, CADMIUM AND LEAD FROM -80° TO 120°C. Arthur J. C. Wilson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read March 9, 1936). This paper is a continuation of the work of Bronson, Chisholm and Dockerty. (H. L. Bronson, H. M. Chisholm and S. M. Dockerty, Canadian Journal of Research **8** 282-303 (1933). S. M. Dockerty, Canadian Journal of Research **9** 84-93 (1933).) The heat capacities of silver, nickel, zinc, cadmium and lead have been measured in the temperature range -80° to 120°C. The method used was the adiabatic electric heating of a kilogram or more of the metal being investigated. The measured values of the heat capacities were plotted against the temperature on large graphs and a smooth curve drawn through the points. The average deviation of the points from the curve was considerably less than .1% in all cases. The following equations have been found to fit the curves with the maximum deviations noted:

for silver	$C_p = D(220/T) + 1.23_3 \times 10^{-5} T^{1.16}$	maximum	deviation	.04%
for nickel	$C_p = D(372/T) + 3.64 \times 10^{-6} T^{5/3}$	"	"	.1 %
for zinc	$C_p = D(235/T) + 3.75 \times 10^{-6} T^{3/2}$	"	"	.07%
for cadmium	$C_p = D(160/T) + 9.63 \times 10^{-7} T^{5/3}$	"	"	.1 %
for lead	$C_p = D(88/T) + 3.06 \times 10^{-6} T^{1.38_3}$	"	"	.15%

where $D(\Theta/T)$ represents the Debye function and the units are joules /gram°C. A discussion is given of the theoretical significance of the constants in these equations.

SMOKE-CURING OF FRESH FILLETS. E. P. Linton and D. LeB. Cooper. Fisheries Exp. Sta. (Atlantic), Halifax, N.S. (Read March 9, 1936). Variables affecting the smoking of fresh fillets were investigated experimentally. These include type of smoke, velocity of the smoke system, and psychrometric conditions inside the smoke hold or tunnel. The results show that if suitable conditions be maintained fresh fillets may be cured in two to four hours. This compares with the present practice of smoking for eight to eighteen hours. Differences in types of products are discussed.

OBSERVATIONS ON THE DEVELOPMENT OF STORAGE SCAB OF APPLES. J. Fred Hockey, Dept. of Botany, Acadia Univ., Wolfville, N.S. (Read April 8, 1936). Climatological conditions during the autumn of 1933 provided suitable moisture and temperature for three complete cycles of infection prior to harvest. It was found that storage scab was the symptom produced from late season infection by conidia of Venturia inaequalis (Cke.) Wint. prior to harvest. Storage of fruit from five to twelve weeks, depending on the temperature, was necessary before the symptoms developed. Fungicidal dips at harvest failed to prevent the appearance of the disease. It was apparent that infections took place prior to harvest.

THE METABOLISM OF DEVELOPING SALMON EGGS: A QUANTITATIVE STUDY OF THE TOTAL FAT CONTENT. D. M. Ross, Dept. of Zoology, Dalhousie Univ., Halifax, N.S. (Read April 8, 1936). The fat content of the developing salmon has been studied from fertilization to the end of the yolk sac period. The range covers 103 days and the average temperature at the beginning was 6°C. and at the end 9°C. 40 samples of 100 individuals each were taken, including unfertilized eggs, unhatched eggs, larvae, shells and separated yolks and embryos. The lipoids were extracted wet with alcohol-ether, re-extracted with petroleum ether and estimated by Backlin's micro carbon combustion method. A drop of 62% in the fat of the embryonic system has been recorded. This drop appears to be confined to the last four weeks of the yolk sac period. Fat is stored rapidly in the embryo up to the hatching period when the process falls off completely. It is resumed about ten days later. The maxima for the rates of fat combustion and of fat storage by the embryo occur at the same time, during the fifth week after hatching. The variation in the intensity of the fat absorption process has been calculated and the results compared with similar data for the chick.

PLEOCHROIC HALOES OF THE THORIUM FAMILY. D. P. Crawford, Dept. of Physics, Dalhousie Univ., Halifax, N.S. (Read April 8, 1936). These haloes, which are quite rare, have been studied by means of the halo photometer. All the alpha particles from the thorium family have been accounted for and the ring radii are in good agreement with values obtained in present day laboratory experiments. A discussion is given of errors involved and accuracy obtainable by this method.

THE SEPARATION AND CHARACTERIZATION OF THE PROTEINS OF EGG WHITE. E. Gordon Young, Dept. of Biochemistry, Dalhousie Univ., Halifax, N.S. (Read May 4, 1936). The proteins of the white portion of the hen's egg have been separated into several fractions by two methods. These fractions have been analysed and compared mainly to determine the extent and behavior of the mucoproteins present. Analyses for nitrogen, sulphur, cystine and glucosamine have been performed. The absence of ovoglobulin is maintained. Ovomucin has been found possessing characteristics which distinguish it from other mucins and which depend upon the mode of isolation. The nature of the chalazae has been determined from analytical similarity to be that of ovomucoid. The separate identity of these fractions in natural egg white is questioned.

Further Studies on the Breakdown of Complex Molecules. J. R. Dacey and N. A. D. Parlee, Dept. of Chemistry, Dalhousie Univ., Halifax, N.S. (Read May 4, 1936). The investigation of the effect of structural changes on the stability of ethylidene diacetate homologues has been continued. The replacement of H by Cl atoms does not change the activation energy but does decrease the probability of reaction. The replacement of a H atom by a phenyl group increases the reaction rate and lowers the energy necessary for reaction. The results to date are discussed from the point of view of modern theories of intramolecular energy exchange.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper should be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½ x 11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review". A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, (7) **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76 (1927); C.A., **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts". In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**, vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper or on tracing linen. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. The Institute bears the expense of a limited number of cuts only. Where necessary half-tones for reproduction on special paper will be accepted at the author's expense.

Unless page proofs are specifically asked for, galley proofs only are sent to the author for correction. Proofs should be corrected with great care and returned by next mail to the Editor, Dr. Harold S. King, Dalhousie University, Halifax, N. S.

The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOL. XIX. 1936-1937 PART 3

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PROCEEDINGS
OF THE
Nova Scotian Institute of Science

SESSION OF 1936-1937
(Vol. XIX, Part III)

6253

Museum of Comparative Zoology
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THE ORGANIZATION OF RESEARCH IN CANADA*

MAJOR-GENERAL A. G. L. MCNAUGHTON,
President of the National Research Council,
Ottawa, Canada.

I count it a very high privilege to be with you to-night and to have the honour of speaking to you on the occasion of the celebration of the 75th anniversary of the foundation of your Institute.

I join in the congratulations which you have received on this event, and I bear tribute to your founders for the vision which they displayed and to their successors in office down the long span of intervening years, who have maintained the traditions and given to the scientists of Nova Scotia, and to those interested in science, a forum where papers could be presented and discussed; where friendly personal contacts could be made and information exchanged among workers in allied fields. Experience since the earliest days of the Royal Society of London has shown that such institutes are essential if men of science are to be developed and given a proper opportunity of making their contribution to the great stream of information which year by year adds to the knowledge of mankind and the advancement of science. The City of Halifax and the Province of Nova Scotia are indeed fortunate that this need was early recognized and provided for.

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*Condensed from an address to the Nova Scotian Institute of Science on the occasion of the 75th anniversary of its foundation Halifax, 15 February, 1937.

I am to speak to you tonight about research in Canada: why it is necessary; how it is organized; what it has accomplished; what the future holds. In the course of my remarks, I hope to give you some idea of the tasks which have been assigned by Parliament to the National Research Council; of the organization which has been built up to carry them out; of the progress which has been made; and of our plans for development to meet the ever increasing needs of Canadian industry.

Recently, the secretary of one of our large associations wrote to me that "the stage of convincing the people that industrial research is useful and necessary is pretty well passed." I wish I could agree with him, but I am afraid the situation has not yet developed to that happy state where we can take a recognition of necessity and the provision of adequate facilities and support for granted; and, while I am convinced that there is an increasing understanding of the need for organized industrial research, I have not found it so general that we can obviously count on getting what we need.

For this reason, I welcome this opportunity to go briefly into the general situation, and to stress the urgent need in this country of paying more attention to research in all its various branches.

The civilization in which we live is distinguished from those of the past by its high complexity, by which I mean that no individual or family or even group of families is any longer a unit in producing the things or rendering the services which are required in daily life.

In our grandfather's day, life went on much as it had for the previous thousand years or so. The farmer tilled the field and harvested his grain which he took to the local mill to be turned into flour; the shepherd tended his flocks and the wool was worked into clothing in the homes of the inhabitants; transport depended on the horse, and the village wheelwright produced from local material such simple vehicles as were needed; wood supplied the requirements for fuel;

tallow made candles for light; really about the only thing which had to be imported into any typical community was iron and this was needed only in strictly limited quantities.

During the last hundred years this simple system of life has all been changed, and the change has been the *consequence of specialization.*

When men specialize they acquire not only manual skill through which the product of their labour is greatly increased, but they also acquire knowledge of a particular trade, and this special knowledge in the minds of certain individuals is the mother of invention. Out of this came the marvelous advance in the mechanical arts which has taken place and the far-reaching applications of machinery to ease the task and multiply the power and speed of man. In the result, articles are made available in quantity to all for daily use, which in a previous age would have been luxuries, unattainable even for the wealthy.

We have become accustomed and have adapted ourselves to this higher standard of living and we would not go back. We could not if we would, for populations have developed which could not exist on the basis of a primitive civilization and people would have to die by the thousands and tens of thousands if there were retrogression.

It seems that man can adapt himself without difficulty to an expanding civilization, but in a reverse case, or if he stands still, he perishes. It is the business of research to serve an expanding civilization; to find new and better methods of satisfying old requirements; to open the way to new services needed by the public; and to create the materials and technique by which they may be developed. Nowhere in all the wide range of sciences is any limit in sight—progress continues at an ever increasing rate and the future is beyond conjecture.

In the days of the stage coach the maximum distance which could be traversed in a day did not exceed about 100 miles. Voyages by sail across the oceans were matters of months. Today aircraft cruise at over 250 miles per hour and telegraph and telephones link the continents in instant communication. Measured on a time scale the earth has shrunk and there would perhaps have been no objection to this if the moral side of civilization had kept pace with the material, so that the nations might have learned to work in co-operation and with mutual consideration and forbearance. Unfortunately, this does not seem possible and the world, as we know it today, has become highly nationalized and competitive.

If we fall behind in the struggle we face disaster just as certainly as did the tribal peoples of early history. To them the penalty of failure was mercifully swift; to us it may be long drawn out but none the less unpleasant on that account.

In the past, the conflict between nations was carried out by armies and navies; today the arena of the struggle, except for rare intervals, has shifted to industry and the prize is markets. So predominatingly important has industry become that unless a nation is highly developed in this respect it is no longer possible for it to have effective armed forces for defence, and so it lives precariously at the whim of others.

Thus the efficiency of industry, and I use the term in the broadest sense, is a matter of vital concern to everyone. It is the business of the research organizations of a nation to promote this efficiency in every way; to assist in turning every national resource and facility to account; to improve processes and to cheapen products so as to better the competitive position of their country in the markets of the world, and particularly to be ready to suggest new articles of manufacture when the fashion for the old diminishes or they stand in danger of being displaced. It is to these activities in aid of Canadian industry that the National Research Council is dedicated.

During the last half century or so the industries of the world have been modified and built up on the basis of scientific knowledge. The mechanical industries derive from Newton's laws of motion; the electrical industries are based on the early scientific work of Henry, Faraday, Maxwell, Ampère, and down the years through Edison and a multitude of others; aviation is the outgrowth of hydrodynamics and aerodynamics; the chemical and metallurgical industries make use of knowledge accumulated since the days of the alchemists.

Most of this fundamental information, which has made modern industry possible, was built up slowly in the universities of the world. It was not acquired for any utilitarian purpose, it came as a by-product in the search for truth. This form of research has in consequence come to be called "pure science", and it continues to hold a most important place in the scheme of things as they are.

Until towards the end of the last century only a relatively small fraction of the fundamental knowledge which had been acquired and stored up by the universities had been assimilated by industry and new knowledge was accumulating perhaps faster than it could be made use of.

In this period all industry had to do was to exploit the existing stores of information, but even for this trained minds were needed, and there was a demand for men who could understand the facts and apply them to the everyday problems with which they were faced.

Experience showed that men who had been trained in the universities in the fundamentals of mathematics, chemistry, physics, etc., were particularly useful, and, first in the larger manufacturing establishments and later extending in ever-widening circles, there began to grow up organizations for what was called "Applied Research".

Applied research was something that most business men of that day could understand. It was immensely profitable. In contrast "Pure Research" was deemed academic and the men who engaged in it were thought of as people who were not practical. Business was then quite content to leave to the universities the pursuit of knowledge for its own sake.

At the beginning of this century some forward-looking leaders of industry recognized that industrial application had nearly overtaken the capacity of the universities to produce new facts to work on, and out of this idea "Industrial Research" was born.

On this continent the first step was taken in this direction in 1901 by Mr. E. W. Rice of the General Electric, who established under Dr. Whitney the first industrial research laboratory for the purpose of carrying on fundamental industrial research; that is, the acquisition of new scientific knowledge and the discovery of applications for this new knowledge. This new form of research, backed by the large resources of a great company, was to accelerate scientific progress and to extend the frontiers of human understanding.

Dr. Langmuir, who succeeded Dr. Whitney, has rightly observed, "Such research work cannot usually be directed towards definite goals for it involves unknown factors. Success if attained is often reached by wholly unexpected methods and the problem which is finally solved is not the problem which was foreseen."

That the idea of fundamental industrial research was "practical" has been amply proved. In the field of lighting alone three major improvements came out of the organization which Rice created, and these, in their result, decreased the cost of illumination by four-fifths; it has been estimated that on present costs for electrical power and rates of use the saving to the public on this continent, brought about by the modern lamp as compared with the carbon filament, amounts to some 5 million dollars a night. It has been further estimated that for every dollar of profit made for the company by innovations developed in this laboratory, the public has been saved from 10 to 100 dollars.

The example set by the General Electric was quickly followed and many of the larger industrial corporations now maintain departments of considerable size devoted to industrial research; for example, the Bell Laboratories in New York, concerned with solving problems in the sphere of electrical communications, have a staff of some 4,000 persons of whom about one-third are scientists holding graduate and postgraduate degrees.

I want now to turn your minds back for a decade or so and to ask you to look at Germany where Research—Pure, Applied and Industrial—had early been recognized as a matter of profound concern, and where its organization and correlation had been taken under the auspices of the government. Under this jealous care every idea and invention was seized upon and subjected to intensive development at the hands of large groups of trained scientists; eager business men stood ready to exploit whatever they produced.

There are many in this room to-night who will remember how this and the neglect of other nations had reacted on German world trade to the point that eminent authorities have said that in 1914 she had no need to embark on war of the older fashion in order to become mistress of this globe. The prize was within her reach and it was only her impatience which eventually caused her to be set back.

You know also of the great difficulties which faced the Allies on the outbreak of hostilities by reason of the German monopolies. The German dye industry, for example, which had taken the invention of a British chemist and turned it into a great commercial undertaking, led directly to efficiency in the production of explosives and of poison gas.

I have often wondered why this menace was suffered to develop without adequate counter measures being taken, and it seems, on looking back, that its very gradualness must have been the answer, men's minds becoming accustomed to it by degrees. It is true that in England before the war they still had the momentum of the earlier industrial development, the individual initiative of their captains of industry and the skill of their workmen as assets which had not yet been overtaken, while we in Canada could think that our boundless natural resources and our virgin wheat lands would provide an inexhaustible treasure for which we could draw tribute from all the world.

The impact of the war shook the complacency of the British peoples, and it was out of that event that our organized research was born, and this was true in the United Kingdom, in Canada, and, also, to some extent, in the U. S. A.

Great as was the contribution made by our manhood on the field of battle, great as were the triumphs of our armed forces, it seems, on sober reading of the histories of those times, that at least an equally essential contribution was made by industry, once scientific and industrial research was organized and brought into play.

To illustrate what was accomplished in Great Britain, I mention a few significant facts.

In 1914 there was no optical glass industry in the United Kingdom. Germany and Austria had a practical monopoly in this field and even the lenses for the sights of British guns were imported. Organization of the scientists in 1916, followed by extensive basic and applied research, corrected this situation. Today, the optical glass produced in England is of the finest quality in the world. They are self-sufficient not only for defence, but in the peaceful arts as well, and under the watchful eye of a committee of the Department of Scientific and Industrial Research there is no danger of a failure in this field.

I mentioned poison gas. Chlorine, a product of the German chemical industry, was used against the French and the left flank of the 1st Canadian Division on 22 April, 1915. The Germans used it because they thought the Allies would not be able to reply in kind—they were contemptuous of our scientific organization—but by the summer of 1918, as a result of organized research, our chemical industries were producing "mustard" by a new process at a rate many times that which had been found possible in Germany.

There are here in this city men who had a hand in organizing Canadian industry for war, and who took part in the great investigations and research which that enterprise demanded. They can be rightly proud of what they accomplished and of the team play and co-operation which marked that undertaking under the leadership of Sir Joseph Flavelle, who continues to this day to take a great interest in the Ontario Research Foundation, which he was instrumental in establishing. To illustrate the magnitude of their achievement I mention one isolated fact alone: for the year 1917 Canada produced over

46 per cent of the field gun ammunition acquired from all sources for the British armies, and, in addition, substantial quantities for our allies, France and Russia.

I have heard it stated that Canadian shells were as low priced as any, so our industry was efficient. I myself and others here can bear witness to the high quality of the product.

Apart from every other advantage, the financial benefits from this industry went a long way to saving Canada from bankruptcy and enabled us to continue with our forces in the field unimpaired until the end.

As I have said, the organization of research in Canada, as a function of Government, dates back to the impact of the war. In 1916, Canada, following the example of the United Kingdom, established an Honorary Advisory Council for Scientific and Industrial Research.

It was not contemplated at that time that this Council should set up laboratories of its own; it was to act as an agency for consultation and co-ordination between those already carrying on research in the established laboratories of the several departments of the Dominion and Provincial Governments, in the universities and in industry.

To give you some idea of the very limited facilities then available—a report prepared at the time indicates that the annual expenditure on research in all governmental laboratories, Dominion and provincial, amounted to considerably less than $100,000, and that of some 2,400 leading Canadian firms engaged in manufacturing, who replied to a questionnaire, only 37 had laboratories which even pretended to engage in research. The total annual expenditure of these firms for research and testing, apart from salaries, the figures for which are not available, amounted to some $135,000. That is, and making a liberal estimate for the cost of research in the universities, the total expenditure for all agencies in Canada must have been considerably less than half a million dollars annually.

Looking back at the history of the Honorary Advisory Council for Scientific and Industrial Research, it is remarkable what has been accomplished with the limited facilities at their disposal, but it is not to be wondered at that men, who were informed on the subject, should have realized the utter inadequacy of the provision which had been made and that they should have pressed for some improvement. As a result of this pressure of public opinion, the matter was repeatedly considered in Parliament and, eventually, the Research Council Act was passed in 1924 under the guidance of the late Honourable James Malcolm, then Minister of Trade and Commerce, and the construction of new laboratories on Sussex Street, in Ottawa, commenced. These laboratories were opened in 1932. As was perhaps to be expected, the appropriations made available during the period of depression were on a substantially lower scale than those planned, and, as a consequence, the organization, both as regards staff and equipment, is far from complete. It is now our business to rectify these deficiencies and the only way in which it can be brought about is to see to it that, with what we have, a service of value is given to the public.

The National Research Council today consists of 15 members selected, for terms of three years, from among men prominent in scientific work in our Canadian universities or in Canadian industry. The Council is required by statute to meet at least four times annually in Ottawa. There is a President, appointed by the Governor-in-Council for a term of years, who reports directly to the Privy Council Committee on Scientific and Industrial Research, of which the Minister of Trade and Commerce is the chairman.

The Council's membership is broadly representative of all parts of Canada and includes persons qualified to speak authoritatively on education, science, industry, business and finance. From Nova Scotia, Dr. A. S. Mackenzie was appointed when the Council was first established in 1917, and I am glad to say he is still a member and that he continues to attend our meetings regularly.

The Council is a body corporate, capable of suing and of being sued, of acquiring and holding money, property, etc. By statute the "Council in addition to certain specific duties set forth in the Act shall have charge of all matters affecting scientific and industrial research in Canada which may be assigned to it by the Committee of the Privy Council."

Apart from administration, which is organized much on the usual lines of a department of Government, the staff of the Council is grouped in a number of divisions, each under a director: Research Information, concerned with the collection, collation and issue of scientific information and with the general planning of co-operative investigations through committees, etc.; the Divisions of Biology and Agriculture, of Chemistry, of Physics and Electrical Engineering, of Mechanical Engineering, including Hydraulics and Aeronautics, etc., are each responsible for the direction and conduct of technical work in the fields indicated by their designations; provision is made for the closest co-operation and collaboration between all branches concerned in any particular problem. At the present time the staff comprises a total of 163, of whom 67 are graduates or post-graduates. There are also 31 additional research workers, of whom 9 are graduates, employed directly under committees.

In order to bring to bear the knowledge of scientific men and industrialists, and to correlate the work of all research organizations concerned, a number of so-called associate committees have been set up. These meet as the occasion may require, but in this era of limited finances much of their work has necessarily to be done by the less satisfactory method of correspondence.

The function of these committees is to direct co-operative research on the problems assigned to them; to settle the objectives; to indicate the individuals or organizations which should undertake the several component parts of the inquiry; to receive and co-ordinate the resulting information; and to make it available to those who will turn it to advantage.

I would, by way of illustration as to the procedure, like to tell you something of the Associate Committee on Forestry Research, which has just recently been established, because I think this example will indicate the manner in which all available information can be assembled and brought into correlation, and through which the necessities of the situation can be determined and action promoted. The Associate Committee on Forestry Research had its genesis at the Petawawa Research Station in a joint meeting of the Canadian Society of Forest Engineers and the Woodlands Section of the Canadian Pulp and Paper Association. There, the field was canvassed, and it was brought forcibly to attention that while there were a number of organizations at work in matters connected with forestry research yet it did not seem that the information was being properly brought together and harmonized. The meeting passed a formal resolution asking the National Research Council to undertake this task. I may say that we very gladly undertook to do so, and as a first step a conference was called of all organizations concerned, federal and provincial, public and private, including a number of industrial concerns. The whole field was traversed and definite conclusions reached, and as a result the Council set up the Associate Committee on Forestry Research, which comprehensively represents the whole industry and to which all concerned can look for correlation in their efforts, and for a national plan into which they can fit their own particular lines of research. It is astonishing what can be done by goodwill and co-operation, and it is a most happy augury for the future when one sees, as I see in that committee, all who are concerned in Canada coming together for a definite common purpose.

In order to make use of the facilities for research which exist in a number of our Canadian universities, the Council in the early years of its existence, developed a system of "Assisted Researches" so that projects of importance, which otherwise could not be undertaken, would proceed under the competent direction of members of a university staff. An application for any particular investigation, setting forth the proposal in detail, its objective, the facilities available, the assistance required and the estimated cost, is submitted by the professor in charge through the head of his faculty to the National Research Council where it is reviewed. Any grants which are made are restricted to the provision of needed apparatus, hire of labour, travelling expenses, etc., and no contribution whatever to the salary of the applicant is made. Through these grants much useful work has been accomplished and it is hoped that as more funds become available they may be given in larger numbers.

In order to provide for the advanced training of selected young Canadian scientists, the Council each year grants a number of scholarships, which may be held at Canadian universities or in exceptional circumstances at selected educational institutions abroad. For the current year awards have been made to 30 students. These were selected from some 87 promising applicants so it would appear that this branch of our activities could be increased with advantage. I would say that the Council's Scholarship Committee, of which Dr. A. S. Mackenzie is the Chairman, are deeply sensible of this need and that, in accordance with their recommendation, the Government has seen fit to nearly double for the next year the provision which was previously made. Half of the additional funds will be devoted to increasing the number of ordinary scholarships which the Council awards, and half will be devoted to new classes of scholarships which have been instituted at the instance of some of our Canadian universities, and which are designed to open the special facilities which are available in the laboratories of the Council to selected post-graduate students who, otherwise, might have to go out of Canada to pursue their chosen lines of research. The National Research Council is not a university and has no intention of entering this field except by way of assistance and on request.

No student will be accepted for these special scholarships unless one of our universities so requests, and gives assurance that his work with us will count towards the higher degree to which he is proceeding. We have made limited provision also to receive some post-Ph.D. students to bridge the gap between their academic training at their university and their absorption in some specific Canadian industry.

I would like now to direct your attention for a few minutes to certain aspects of industrial research in Canada which merit consideration. The truth of the matter is that we are not doing nearly enough work of this character; that we are allowing ourselves to remain in a position of dependence upon other countries; that for this we are paying tribute on an enormous scale; and, worse, we are not obtaining and passing on to the Canadian people the benefits which they have every right to expect. As is well known, most of our principal industrial companies have affiliations with larger organizations abroad to whom there has been a natural tendency to refer any research problems that arise from time to time. It is often very difficult to examine these problems completely, apart from the special environment in which they have come to attention and the solutions proposed are often, therefore, inadequate, and, both on this ground and on account of delays, very heavy losses are involved. A more serious loss is due to the fact that without a corps of trained investigators on the spot, the needs of the situation are not fully appreciated and many opportunities for useful inventions and developments are missed or unduly delayed.

One of the things about organized industrial research, which has been impressed upon me in many discussions which I have had on this subject, is the curious difficulty there seems to exist in getting people to think about it in terms of economics, and this is true even with engineers and business executives who are accustomed to applying the well known principle of "least costs" in their everyday decisions.

When it comes to research, in place of balancing resulting savings against their cost you meet with this sort of statement, and I am quoting from responsible authorities: It has been publicly stated in England that electrical research which cost some £80,000 is now estimated to be saving that industry not less than £1,000,000 per annum. Also in the iron and steel industry co-operative research led to a saving of £400,000 per annum in coke alone, and of £1,500,000 in finished steel; and one small project in flax development put an extra £60,000 into the pockets of the growers last year.

These results are no doubt gratifying to the men engaged in the researches in question, but the analysis of the figures shows that an annual benefit has been derived perhaps a hundred times greater than the total expenditure on the research which brought it about. Does this not indicate and prove that not nearly enough research has been done?

I believe the best way to obtain a view of our position in respect to the adequacy, or otherwise, of our attention to research is to take the situation which exists in some other country and to measure our own facilities against it. For the purpose of this comparison I have chosen Russia, partly because we happen to have very complete information available as to what they are doing there in the realm of scientific research, and partly because of the similarity of their conditions and natural resources to those which we have in Canada. On account of this similarity we have to foresee their production of the same things as ourselves for sale in the markets of the world.

The annual expenditure on the Russian Academy of Science, which is only one of their many agencies for research, mounted from about four million roubles in 1928 to 17 million in 1933 and to over 44 million in 1934; that is an eleven-fold increase in a period of six years. Altogether in Russia there are in existence 840 institutes engaged in research, which is twice as many as in 1930, and in these, in 1934, 47,900 persons were engaged in research work. Their annual expenditure on research is reported to be now in excess of 500 million dollars and is planned by the end of 1937 to have a capital investment of some 2,000 million dollars. These are large figures. The latest information we have shows that the budget for Russian research continues to increase just as fast as they are able to produce new trained workers through their modernized educational system and it is clear that no limit has yet been set. We know—and it is significant—that the leaders of their defence forces are attaching the greatest importance to the pressing forward of these various organizations for research. Russia has a population of 186,000,000, which is some 20 times ours. If you divide their figures by 20 it will give you an idea of what we would have to spend and what effort we would have to devote in Canada to this problem if we were to raise the intensity of our effort to the level of what is actually being done in Russia at this present time.

If you divide the Russian research workers by 20 it gives 2,500. If you divide their current expenditure by the same figure it will give $25,000,000 per annum. We have in our own National Research Council employed at the present time a total of 194 scientific workers and assistants, and we have an annual budget, apart from what we receive from industry, of $621,500. This does not tell the whole story, because there are other departments of the Federal Government which have responsibilities for research from the national point of view, and there are a few other organizations, such as the Ontario Research Foundation under Dr. Speakman, which are taking an interest in certain national aspects of research. But nevertheless this comparison indicates that our provision has been very far short.

Again, I would remind you that in the principal industries of this country we are dependent for our research on our friends from across the border, and in Europe, and, while we appreciate that assistance and service, I do think that, in our own interests, it is wrong to continue to depend on it.

It is wrong from many points of view, not the least of which is that the young research workers whom we are training in our university courses and scholarship schemes are leaving us. They have to go abroad for employment. It has been my business to try to bring some of them back, but when we have one position available for a research worker I find anything up to 70 fully qualified applicants, any one of whom I would have been glad to have working on our staff.

Compare this with Russia where they are pouncing on every qualified man and turning his brains to service on national account to improve their position. On the other hand, we are dissipating our resources and not using the brains that have been given to this country. Our men are making a contribution in foreign lands but they ought to be making it in Canada. We are willing to share the fruit of their labours with other countries but we would like to see them doing their work where Canada would get some credit and where it would redound to our national advantage.

In Russia, we have the case of a country which was formerly one of the most backward in the world in industrial development. Leaders of great vision have grasped the opportunities presented by organized research and are dealing with the matter on an adequate scale. Their progressive development is acquiring momentum which bids fair to carry them to a leading and possibly to a predominant position in the world. Considering this can we afford to rest content with our own limited facilities?

I have probably said enough to show that we can by no manner of means afford to regard the situation in Canada with complacency, but on the contrary we should use every endeavour to interest those concerned, and particularly our manufacturers, so that we may conserve what we have in the way of trade in our own markets and in the markets of the world in the face of the ever intensifying competition from new, improved, and cheapened products of other lands.

It seems to me that one of the most important aspects in respect to the organization of our industrial research which must receive consideration is the cost of not doing it. There is no use in resisting the natural trends of development for that is an impossible task. We must put trained investigators to work to find other uses for our products in danger of being displaced, and they must find new products which can be made from available raw materials in order that stability of employment and of capital investment may be maintained, and particularly that the appalling waste and misery which come in the trail of any decadent industry may be avoided.

The nucleus of the organization required to do this work for Canada exists in the National Research Council, which, as I have said before, is dedicated to help Canadian industry, and I can assure you that our staff stands ready and willing to bring our resources to bear on the study of problems whenever required.

From your own experience you are no doubt aware of the great importance of making a close study of the literature before embarking on any research or investigation, for it may be that what you require to know has already been found out and reported, and if not you will at least have the result of other peoples' thought on the matter as a guide to you in your work. Like other forms of research, a study of the literature is a matter for experts specially skilled and experienced in the art and for this reason the Council has established a Division of Research Information which is charged with the duty of doing this work for our other scientific divisions, for our Associate Committees and, within the limitations of staff, for Canadian industry as well.

The Division of Research Information is responsible for the Council's Library, which now contains upwards of 20,000 volumes of reference works and receives annually some 800 scientific periodicals and 300 other serial publications. The aim has been to develop it as a complement to other scientific and reference libraries in the Dominion so that through a loan and photostat service inquirers from anywhere in Canada may be given promptly the information of which they are in need.

The Division of Research Information is also responsible for the editing and publication of the Canadian Journal of Research, which now supplies a medium through which the work of all Canadian scientists can, if they wish, be reported. The Journal now goes to most of the principal libraries and scientific institutions in the world. During my visits to a number of research centres in Great Britain last summer, I was gratified to find well thumbed copies on the tables of a number of workers, and, in discussion, repeated and favourable reference was made to the papers which had been published in it. I, therefore, feel that the Journal is helping in a substantial measure to secure that recognition for Canadian science which is due to the class and quality of our workers. Without the Journal, Canadians would be forced to publish abroad, and the identity of their work would, to a large extent, be lost.

I referred earlier this evening to the progress being made in the United Kingdom in the organization of research. Under the policy of the Department of Scientific and Industrial Research, research associations have been created in the principal British trades and industries. Among others are the electrical and allied industries, iron and steel, non-ferrous metals, refractories, cotton, linen, wool, leather, paint and varnish, automobiles, etc. These associations which are very active in research in their respective fields are open to representatives from the Dominions, and the National Research Council has taken membership in a number of them so that copies of their reports may be available in Canada for reference purposes and such of these reports as are not confidential constitute an important source from which the Division of Research Information compiles answers to inquiries.

I have outlined very briefly the functions of the National Research Council, and I would now like to tell you of some of the work which is in progress in our own laboratories.

The Division of Physics and Electrical Engineering carries the responsibility for the maintenance of the ultimate standards of electrical units, etc., and equipment has been provided so that precise calibration of measuring instruments for industry can be carried out. By statute, the Council's staff are responsible for type approval listing of all meters used for the measurement of electricity for sale; we are now equipped to discharge that duty.

We have a heat laboratory where tests of new types of building material are carried out to determine their thermal conductivities. It is very important that accurate information on insulation should be available to architects and designers so that appropriate steps may be taken to cut down the heat losses.

We have a sound laboratory which is studying questions of acoustics so as to aid in developing new materials and the methods of using them with a view to improving public rooms and even private houses from the point of view of sound absorption.

We have laboratories which do the testing of radio receivers, standardization of sets so as to make sure that the minimum requirements from the point of view of safety, fire hazard and so on have been met. All that work is very detailed and laborious.

Chemistry, since the days of the alchemist, has developed into a very broad subject, and so in our Division of Chemistry we have had to specialize on the problems of first importance. The problems assigned are those concerned with Canadian resources available, if properly used and exploited, to take the place of something which is imported as a finished product. I will mention one or two out of a score of subjects under investigation. Western colloidal clays have been processed to yield a bleaching clay, suitable for use in refining gasoline, lubricating oil and vegetable oils, equal to if not superior to foreign clays which are being imported to the extent of over $300,000 a year. This sum might very well go into the pockets of our own producers and help develop our own industries.

Then there is the question of carbon black. We are vitally interested because we have a great rubber industry and carbon black is used to mix in with rubber to increase its wear resistance. Motor car tires require a considerable quantity and we imported 14,000,000 pounds last year. In the natural gas in the Turner Valley oil fields, we have a material which is going to waste from which our requirements could be met. Our chemists have worked out a process by which that gas can be turned into carbon black with extraordinary efficiency—in fact with some fourfold greater yield than anything achieved in the past. With an efficiency of that sort available, surely we can look to some Canadian industrialist to take hold of these patents and apply them so that we may obtain some value out of that gas which is at present being blown off in the atmosphere at the rate of millions of cubic feet a day.

We use a very large quantity of starch in this country, and that starch is made from material which is imported. We are an agricultural country and it does seem most extraordinary that we should import corn in order to make starch for industrial and culinary purposes. We had a glut of potatoes in the Maritime Provinces a couple of years ago, and the suggestion was made that potato starch might very well be developed to the point that it could take the place of the foreign starch. Comprehensive investigations have been carried out and we now have starches which are quite satisfactory for the textile industry, for plywood manufacture, in the finishing of paper, and recently a process for modifying this potato starch has been worked out so that there is now no technical difficulty in using it both for culinary starch and also for other industries.

As examples of other activities in our laboratories, I would mention: Industrial standardization; safety codes; the discovery of new chemicals which have an amazing effect in promoting the development of root formation in plants and young trees; the new cathode ray compass and direction finder, which promises to have an important place among the radio aids to air navigation, particularly on the trans-Canada airway in the mountainous regions of the west where other methods have proved unsuitable; the Council's work in connection with the establishment of the radium industry in Canada, which was gracefully recognized a few weeks ago by the presentation of a magnificent commemorative plaque of silver; aeronautical research and the testing of aircraft and engines, and the development of new instruments and accessories to meet our special conditions; malting research directed to the testing of new barleys which are being developed to meet the requirements of an important possible market abroad, and of the allied work on hybrid grains through which varieties previously sterile have been endowed with fertility so that their desirable characteristics are now heritable.

The list of work in progress is very long and diverse, and as all projects possess possibilities of economic importance

I would like to have told you about them in detail, but this is not possible as each one is a subject for a full lecture in itself.

There is just one further thought about industrial research which I would like to give you before I bring these remarks to a close and that is, it must be *patient.* I have just been going through the work of one of our co-operative investigations commenced by the Council in 1924, that is twelve years ago. This particular investigation has now at last proved eminently successful and, while the company with which we have co-operated has not yet paid any dividends, I hope the rewards of faith will now not be long delayed. However, what is probably more important than immediate dividends is that the result of this research has changed Canada from the status of importer to exporter of certain key materials vital to the steel industry. It has given a steadily increasing volume of employment and wages have been paid without interruption. The returns to the Council by way of royalties on the product are fully financing the further research in hand, and I have every reason to hope that in due course all our former expenditures will be repaid.

To give an idea of the relative magnitude of other benefits which have resulted, I would mention the fact that the additional freight revenue to one of our railroads which carried the products of this industry now amounts annually to the equivalent of the total of our investment in the investigation to date. Looked at from the point of view of the national balance sheet, the amount of money which now comes into Canada annually, as a result of this one piece of work alone, is in excess of the total being spent on the National Research Council for all purposes.

The requirement of patience and a long-time view is another reason why the leaders of industry should see to it that there is no avoidable delay in placing Canadian research on an adequate and proper basis.

DIFFERENTIATION OF FRESH HADDOCK FILLETS FROM COD BY THE PRECIPITATION TEST.

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ABSTRACT.

Anti-haddock and anti-cod sera were obtained by injecting rabbits with saline extracts prepared from the fresh fillets of these fishes. Using precipitation technique with both antisera diluted 1:10, no distinction between cod and haddock antigens was observed. On repeating the tests with the antisera diluted 1:50 the antigens were differentiated from each other. Control tests using normal rabbit serum in dilutions of 1:10 and 1:25 titrated against cod and haddock antigens did not give any precipitation in antigen dilutions of 1:25 to 1:1000. The following antigens were also tested against anti-haddock and anti-cod sera (diluted 1:10): pollock, halibut, witch, hake and skate. Precipitation occurred with all five antigens; the first two antigens were rich in dissolved protein and gave heavy precipitates, the latter three contained less dissolved protein and the precipitates were correspondingly smaller.

During recent years, with advance of refrigeration, more fish are being placed upon the market in fresh condition, especially in the shape of "fillets". Haddock (*Melanogrammus aeglefinus*) fillets have a particularly wide reputation. Unfortunately substitution by fillets made from other species of fish as, for instance, cod (*Gadus callarias*) or hake (*Urophycis chuss*) for haddock fillets occurs.

Hake fillets are usually quite easily recognized by a fish handler by a simple manipulation. When a haddock fillet is bent, it breaks, while the hake fillet, being much more elastic, does not. On the other hand, there is practically no external distinction between fillets made from cod and haddock. Some dealers, however, claim they can recognize about 25% of the fillets in question, using as a criterion a few ribs left in the fillets. Haddock has stouter ribs, while cod possesses softer ones. Of course, in some cases fillets of these two species may be recognized by their size, cod being much larger. Size alone very seldom counts, because, as a rule, fillets for falsification are cut only from smaller specimens of cod ("market cod").

With a view to finding a distinction between the flesh of the cod and haddock, precipitation tests were carried out. Unfortunately, the authors had very little time at their disposal for this study, and, as the work was undertaken primarily for practical purposes, only general observations were made. It is realized, however, that many important details have been omitted, and hence this article contains only results of a preliminary nature.

The present investigation was carried on in the Pathological Department of Dalhousie University, Halifax, N. S. The authors have the pleasure of expressing thanks to Professor R. P. Smith for the kind permission to use the laboratory facilities for this investigation, to the Biological Board of Canada for permission to devote certain time of one of the authors to this study, and to Mr. W. H. Boutilier, Vice-President of the Maritime-National Fish Co., Limited, Halifax, N. S., for kindly supplying fillets of different kinds of fish for this work.

The precipitation test discovered by Rudolph Kraus in 1897[1] is now widely used not only in medicine as a diagnostic agent, but also for technical purposes; e.g., in the detection of meat adulteration (Uhlenhuth[2]). This test also plays an important role in biology in tracing genealogical relationships between different animal groups. The extensive investigations of Nuttall[3a] may be mentioned in this connection. He tested the blood of more than 500 animal species with about 30 immune sera, making not fewer than 16,000 experiments. In his experiments on fishes he did not use antisera obtained from animals sensitized to fish blood, but only em-

[1] Kraus, R. *Wien. Klin. Wschr.*, **10**, 431 (1897).

[2] Uhlenhuth, P. *Deuts. Med. Wschr.*, **26**, 734 (1900).

[3] a. Nuttall, G. H. F. *"Blood Immunity and Blood Relationship"*, Cambridge University Press. (**1904**). b. ibid. p. 61.

ployed antisera from other vertebrate groups, and also from lobster, using fish blood as the antigen; all these tests were negative.

Following Nuttall's work several other investigations were carried on in order to establish more definitely animal relationships. Boyden[4a], using rabbit and chicken antisera, tried to obtain more accurate results by standardizing the antigens. His work was practically limited to domestic animals and human blood. Precipitation technique in the case of various mammal groups was further elaborated by Wolfe[5] who used a "short method" (3 or 4 injections) in producing antisera. He succeeded in obtaining titers as high as 1:102,400 in the case of anti-mink and anti-fitch sera.

After injections of rabbits with the blood sera of domestic and wild ducks and geese Sasaki[6] was able to distinguish by precipitation tests between different genera. In the case of closely related species, as the wild duck (*Anas boschas*) and its domestic form (*A. domestica erecta*), the distinction by precipitation tests was not so clearly shown. Hicks and Little[7a] demonstrated by precipitation tests the serological identity of two species of mice (*Mus musculus* and *M. faeroensis*), while the Japanese Waltzer and M. *bactrianus* must be included in another group.

Erhardt[8] studied the precipitation tests in the case of invertebrate animals. His experiments showed quite clearly that rabbit antisera reacted not only with the homologous antigens but also with antigens of other species belonging to the same order.

With regard to the work dealing with fishes, the following authors may be mentioned. Tchistovitch[9], who injected eel

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[4] a. Boyden, A. A. *Biol. Bull. (Woods Hole)*, **50**, 73-107 (1926).
b. ibid. pp. 84-88. c. ibid. p. 95, 101.

[5] Wolfe, H. R. *J. Immunol.*, **29**, 1-12 (1935).

[6] Sasaki, K. *Jour. Dept. Agric. Kyushu. Imp. Univ. Fukuoka*, Japan, (**1928**).

[7] a. Hicks, R. A. and Little, C. C. *Genetics*, **16**, 397-421 (1931).
b. ibid. p. 416.

[8] Erhardt, A. *Z. Immun. forsch.*, **60**, 156-166 (1929).

[9] Tchistovitch, Th. *Ann. Inst. Pasteur*, **13**, 406 (1899).

blood into rabbits and guinea pigs, obtained a precipitate when these antisera were mixed with eel blood. Kodama[10], using precipitation and complement fixation tests, studied the differences between the roe of fishes belonging to the sturgeon, salmon, carp and herring families.

Only a very brief description of his technique was given, which is as follows: one gm. of roe was mixed with 10cc. physiological saline and, after storing overnight, the extract was diluted 1:10. From 2 to 4 cc. of the diluted extract was injected into a rabbit every 5 days. Seven days after the last injection the animals were bled, and the antisera obtained. His results showed that antisera obtained for one species gave a precipitate when mixed not only with the homologous antigen but also with antigens derived from the roe of different species belonging to the same family. Slight reactions were obtained in some cases with antigens obtained from roe of other families. Complement fixation tests gave parallel results.

More recently Masuda[11] studied the properties of fish roe and found that marked racial and organ specificity of fish roe protein was shown by the complement fixation and precipitation reactions. Unfortunately, this paper was not available, and further details are lacking.

Throughout the whole period of the present investigation the technique employed was not uniform. During the first part, from June to December, 1935, the rabbits were immunized with diluted (1:20) fillet extracts. The antisera thus obtained failed to show precipitation even with the homologous antigens. In order to obtain satisfactory antisera, a more concentrated (1:4) fillet extract was employed for injections during the second part of this study.

As the method employed very often affects the results (according to Wolfe[5]) a detailed description of the preparation of the antigens and antisera is given.

[10] Kodama, H. *Arch. f. Hygien*, **78**, 247-259 (1913).

[11] Masuda, Y. *Japan Z. Mikrobiol. Path.*, **27**, 366-383; ibid. 423-437 (1933).

Preparation of Antigen.

The antigen used in the first two series of injections (from June to December, 1935) were prepared as follows. One part of fresh fillet, i.e., prepared from fish caught and stored two to six days on ice at 0°C., was minced, then emulsified with four parts of saline (0.85%). The suspension was allowed to remain in the refrigerator (0° to 5°C.) for about 18 hours, and filtered first of all through gauze, and then through a Seitz filter. The filtrate thus prepared was a clear limpid fluid. The filtrate prepared from cod or haddock will give a faint opalescence in dilutions of 1:20 when heated to boiling and a drop of dilute nitric acid added. The pH of the cod extract was 7.1, that of the haddock 6.8. Accurate analyses of the protein content of the different antigens were not made.

The standard extract (one part muscle and four parts saline) was diluted 1:4 with 0.85% NaCl solution and kept in cold storage room at -12°C. Immediately after thawing the extract was limpid, but if kept at room temperature for five to eight hours it became opalescent. It was also found that storage for several days at 0° to 5°C. did not prevent the solution from becoming opalescent.

The antigen used in the third series of injections (from January 4 to February 14, 1936) and in the subsequent titration experiments was prepared as follows. The fillets were minced and emulsified with five parts of saline. The extract thus obtained was filtered through a Seitz filter, and was not subjected to further dilution. The antigens of this series were freshly prepared each week, part was injected into the rabbits at once and the remainder stored in the refrigerator (0° to 5°C.) for four days when it was used for the second injection.

Experimental Animals.

Four six-months old Chinchilla rabbits, three males and one female, weighing 1-1.5 kgms. were used for this experiment. Two (RC1, RC2) were injected with the cod extract, and two (RH1, RH2) with the haddock.

Preparation of Antiserum.

The method used in preparing the antisera was that outlined by Kolmer[12] with slight modifications.

The first series of injections was started on June 21, 1935, and was carried out as follows: 3 cc. of the diluted antigen (1:20) were injected into the marginal ear vein of the rabbit at three-day intervals, these were followed by three 10 cc. intra-peritoneal injections given at six-day intervals. A period of three months was allowed to elapse and the following series of injections given at five-day intervals 1, 2, 3, 3, 5, 5 and 3 cc. Two weeks more were allowed to elapse and 5 cc. of serum were obtained from each rabbit, and a preliminary estimation of the strength of the antisera was made by precipitation tests (not shown in tables). The tests failed to show the presence of precipitins.

Three months were again allowed to elapse and a third series of injections was commenced on January 4, 1936, the antigen used in this series being the undiluted one. The injections were given at four and three-day intervals, respectively, as follows: 3 and 8 cc. intravenously and injections of 5, 10 and 5 cc. intra-peritoneally. On February 14, 1936, samples of serum were withdrawn from each animal and their titers estimated. The results of these titrations are given in Table 1. On February 19, rabbits RH1 and RC2, were bled and 35 cc. of serum were obtained from each animal. The sera were stored in test tubes in the refrigerator (0° to 5°C.).

The precipitation tests were carried out in ordinary Kahn tubes. In each titration 1 cc. of antiserum was added to an equal volume of antigen. The strength of the antiserum was kept constant throughout the individual experiments, while the concentration of the antigen was varied (Tables 1-6). The method of serial dilutions was used to obtain the different antigen strengths.

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[12] Kolmer, J. A. "*A Practical Text-book of Infection, Immunity and Biologic Therapy*", Third Ed., W. B. Saunders Co. (**1924**).

TABLE 1.

Preliminary Precipitation Tests Made February 16-17, 1936.

Antiserum 1:10 dilution	**Rabbit H_1 Haddock**			**Rabbit H_2 Haddock**			**Rabbit C_1 Cod**			**Rabbit C_2 Cod**		
Antigen dilution	After 45 min.	After 9 hrs.	After 18 hrs.	After 45 min.	After 9 hrs.	After 18 hrs.	After 45 min.	After 9 hrs.	After 18 hrs.	After 45 min.	After 9 hrs.	After 18 hrs.
1/10	pp	PP	PP	pp	PP	PP	p(?)	PP	PP	pP	PP	PP
1/20	pp	PP	PP	pp	PP	PP	p(?)	Pp	Pp	p(?)	PP	PP
1/40	pp(?)	PP	PP	pp	PP	PP	p(?)	p	p	(?)	Pp	Pp
1/80	p	Pp	Pp	p	p	p	(?)	Op	Op	(?)	Op	Pp
1/160	p(?)	p	p	p(?)	p	p	L	L	L	L(?)	L(?)	Op
1/320	(?)	p	p	p(?)	L	L	L	L	L	L	L	L
1/640	L	L	L	(?)	L	L	L	L	L	L	L	L
1/1280	L	L	L	L	L	L	L	L	L	L	L	L
1/2560	L	L	L	L	L	L	L	L	L	L	L	L

P—Large flocculi
p—Small flocculi
p_1—Very Small flocculi

O—Opalescent
L—Limpid

(?)—Uncertain

Results.

On February 16-17, 1936, the strengths of the different antisera which were diluted 1:10 were tested. In Table 1 the titers of antisera C_1, C_2, H_1 and H_2 are given; these were 1:80, 1:160, 1:320 and 1:160 respectively. It will be noticed that the readings made after 45 minutes are practically identical with those made after 9 and 18 hours; the latter two readings however were more sharply defined.

The reactions of the stronger antisera C_2 and H_1 were then further investigated not only with their homologous antigens but also with heterologous ones from the following fishes: pollock (*Pollachius virens*), cusk (*Brosme brosme*), hake (*Urophycis chuss*), halibut (*Hippoglossus hippoglossus*), witch (*Glyptocephalus cynoglossus*) and skate (*Raja laevis*). The results of these tests appear in Tables 2 and 3. It is seen that with antiserum H_1 marked precipitation was obtained, not only with haddock antigen and that of closely related genera[13] as cod, pollock and cusk, but also with halibut. The reaction with hake and with witch was not so strong, and that with skate was extremely weak. The results with antiserum C_2 (Table 3) are practically identical, though slightly weaker than those of antiserum H_1. Only with pollock antigen did antiserum C_2 give precipitation with large flocculi; with the remaining antigens only small flocculi were present.

An additional experiment was made on March 14-15, using the following two dilutions of antisera, 1:10 and 1:50.

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[13] In order to inform readers not familiar with fish systematics, the taxonomic relations between different fishes mentioned throughout this paper are briefly outlined. Haddock, cod, pollock, cusk and hake represent different genera of the Cod family (*Gadidae*). The first three mentioned genera are much more closely related to each other than to the remaining two genera. Cusk and hake on the other hand are more closely related to each other than to the former three. The Cod family constitutes part of a larger taxonomic unit, the order of the soft-rayed fishes (*Anacanthini*). The halibut and witch belong to two closely related families, the Halibut family (*Hippoglossidae*), and the Flounder family (*Pleuronectidae*). Both these families belong to another order, viz., the Flat-fishes (*Heterosomata*). The above two orders are included in the class of true fishes (*Pisces*). The skate belongs to another class of fishes comprising sharks and skates (*Elasmobranchii*). This classification is that of D. S. Jordan, B. W. Evermann and H. W. Clark. *Rep. U. S. Comm. Fish., Part II*, 1-670, (1928).

TABLE 2.

Precipitation Tests with Antiserum from Rabbit H_1 (in dilution 1:10) and Different Antigens, Made February 22-23, 1936. (Readings were made after 18 hours).

Antigen dilution	Haddock	Cod	Pollock	Cusk	Hake	Halibut	Witch	Skate
1/25..........	PP	PP	PP	PP	pp	pp	pp	p
1/50..........	PP	PP	PP	PP	pp	pp	pp	L
1/100.........	PP	pp	pp	pp	p	pp	p	L
1/500.........	p	L	p	p	L	pp	L	L
1/1000........	L	L	L	L	L	p	L	L
Antigen (1/25) control.....	O	O	OO	O	L	O	L	L

TABLE 3.

Precipitation Tests with Antiserum from Rabbit C_2 (in dilution 1:10) and Different Antigens, Made February 22-23, 1936. (Readings were made after 18 hours).

Antigen dilution	Haddock	Cod	Pollock	Cusk	Hake	Halibut	Witch	Skate
1/25..........	pp	pp	PP	p	pp	pp	p	pı
1/50..........	pp	pp	PP	p	p	pp	p	L
1/100.........	pp	p	pp	p	p(?)	p	p	L
1/500.........	p	p	p	p	L	p	L	L
1/1000........	L	L	L	L	L	p	L	L
Antigen (1/25) control.......	O	O	OO	O	L	O	L	L

Antiserum H_1 1:10 gave practically the same precipitation with either cod or haddock antigens. However, the same antiserum in a dilution of 1:50 showed a marked difference. In the case of haddock antigen, precipitation was noticed up to 1:1000 whereas with cod antigen only a very slight precipitation occurred in 1:500 dilution.

Antiserum C_2 in 1:50 dilution showed a difference between cod and haddock antigens. With cod antigen up to 1:1000 precipitation was observed, while with haddock antigen precipitation did not occur in a dilution greater than 1:50.

In order to exclude the possible influence of rabbit serum by itself in precipitation reactions a final control test was made in which the reactions of antiserum H_1 and normal rabbit serum were compared (Tables 5 and 6). Two dilutions of sera were tried, 1:10 and 1:25. From these tables it is clearly seen that, in the case of normal serum in the dilutions tried, no precipitation was observed with either cod or haddock antigens, while antiserum H_1 reacted as usual positively in both dilutions.

Discussion.

By comparing the reactions of antisera C_2 and H_1 with haddock and cod antigens, it will be seen that certain discrepancies apparently are present. Thus, for example, antiserum H_1 in a dilution of 1:10 tested against haddock antigens, prepared from different fillets (specimens), gave the following titers: 1:500 (Table 2), 1:1000 (Table 4) and 1:100 (Table 5). These differences are most probably explained in light of Boyden's work[4b] in that the titer of an antiserum varies directly with the concentration of soluble protein in the antigen used.

Although the technique of the preparation of the antigens used by us was uniform, the amount of protein extracted may have varied considerably in the individual specimens. Thus, the protein concentration of the haddock antigen in a dilution of 1:100 (Table 5) may be equal to that of the haddock antigen diluted to 1:1000 referred to in Table 4. This is substantiated by the fact that haddock flesh during and immediately after spawning is poorer in protein than that of fish taken in winter months (Vladykov[14]). Hence, in experiments made in February and March (Tables 1-4) the fillets were

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[14] Vladykov, V. D. *Jour. Biol. Board Can.* in press.

TABLE 4.

The Precipitation Test with Antiserum in Different Dilutions, March 14-15, 1935. (Readings were made after 18 hours).

Antiserum	Rabbit H_1: 1/10		Rabbit H_1: 1/50		Rabbit C_2: 1/10		Rabbit C_2: 1/50	
Antigen dilution	Haddock	Cod	Haddock	Cod	Haddock	Cod	Haddock	Cod
1/25	PP	P	PP	pp	PP	PP	p	pp
1/50	PPP	PPP	P	p	p	pp	p	p_1
1/100	PPP	PP	P	p	L	pp	L	p_1
1/500	pp	pp	p	p_1	L	p	L	p_1
1/1000	p	p_1	p	L	L	p	L	(?)
Antigen (1/25) control	p_1p_1	p_1p_1	p_1p_1	p_1p_1	p_1p_1	p_1p_1	p_1p_1	p_1p_1
Antiserum control	L		L		L		L	

no doubt richer in protein than those used in experiments performed during April (Tables 5-6) when the haddock were "spent". These remarks are applicable to cod antigens also.

As the main object of this work was to find by precipitation tests a distinction between cod and haddock fillets and, since both these species are closely related from the taxonomic standpoint, a distinction between them by serological methods involves certain difficulties (Landsteiner[15a]). Moreover, according to Johnston[16], protein solubility of both is practically identical.

In the experiments (Tables 2-4) when the protein concentration in the antigen used was presumably high, both antisera H_1 and C_2 (in dilution 1:10) showed practically the same precipitation with either cod or haddock antigens. With antisera diluted 1:50 (Table 4) a certain specificity was noted. Antiserum H_1 gave a marked precipitation with the homologous antigen up to 1:1000, whereas with cod antigen slight precipitation was observed in dilutions up to 1:500. Antiserum C_2 with haddock antigen only showed precipitation in dilution of 1:25 and 1:50, whereas with homologous antigen precipitation was noticed up to 1:500. Unfortunately the small quantity of antisera remaining did not permit further observations.

The use of diluted antisera was in accordance with Dean's[17] recommendation, who stated that: "if the antiserum is to be used for the differentiation of the homologous serum from the serum of nearly allied species it is important to use the antiserum in the highest dilution which will yield visible precipitates when mixed with dilutions of the homologous protein."

Antigens prepared from pollock, cusk and halibut react with either H_1 or C_2 sera practically to the same titer as haddock and cod antigens (Tables 2 and 3). Both antisera,

[15] a. Landsteiner, Karl, "*The Specificity of Serological Reactions*", Charles C. Thomas, Baltimore (**1936**).
b. ibid., p. 13.

[16] Johnston, W. W. *Biol. Board Can. MS. Rep.*, No. **29**, 11 pp. (1930)

[17] Dean, H. R. "*A System of Bacteriology*", Vol. 6, p. 428. His Majesty's Stationery Office, London (**1931**).

TABLE 5.

The Precipitation Test with Antiserum and Normal Rabbit Serum and Haddock Antigen, April 5-6, 1936.

Serum	Rabbit H_1: 1/10		Rabbit H_1: 1/25		Rabbit N: 1/10		Rabbit N: 1/25	
Haddock Antigen	After 6 hrs.	After 24 hrs.	After 6 hrs.	After 24 hrs.	After 6 hrs.	After 24 hrs.	After 6 hrs.	After 24 hrs.
1/25	PP	PP	pp	ppp	L	L	L	L
1/50	pp	PP	p	p	L	L	L	L
1/100	p	pp	L	p	L	L	L	L
1/500	L	L	L	L	L	L	L	L
1/1000	L	L	L	L	L	L	L	L
Antigen (1/25) control	p	p	p	p	p	p	p	p
Serum control	L	L?	L	L	L	L	L	L

TABLE 6.

Precipitation Test with Antiserum and Normal Rabbit Serum and Cod Antigen.

Serum	Rabbit H_1: 1/25		Rabbit N: 1/10		Rabbit N: 1/25	
Cod Antigen	After 6 hrs.	After 24 hrs.	After 6 hrs.	After 24 hrs.	After 6 hrs.	After 24 hrs.
1/25	ppp	ppp	L	L	L	L
1/50	p	pp	L	L	L	L
1/100	L	pp	L	L	L	L
1/500	L	L	L	L	L	L
1/1000	L	L	L	L	L	L
Antigen (1/25) control	p_1(?)	p	p_1(?)	p	p_1(?)	p
Serum control	L	L	L	L	L	L

on the other hand, only gave precipitation with skate antigen in a dilution no greater than 1:25. The reactions with hake and witch antigens are intermediate in position between the above two groups. These variations in titers are believed to be due to differences in the concentration of soluble protein in the various antigens, and are not attributed to zoological relationships. Of course this conclusion must be substantiated by determination of the soluble protein in the antigens used.

In the literature quite often the degree of relationship between the animal species furnishing the antigen and that used for immunization is considered important in precipitation tests. Nuttall[3b] and Boyden[4c], for instance, believed that an animal far removed phylogenetically from the one to be tested is the most desirable as the antibody producer. Sasaki[6] succeeded in distinguishing between different species of ducks by using rabbit antisera, and, even in the case of invertebrates, rabbits were found suitable (Erhardt[8]).

On the other hand Hicks and Little[7b], Landsteiner and many others consider as the best antibody producer an animal quite closely related zoologically to those to be tested. For instance, using rabbit immune serum, different species of mice can be differentiated (Hicks and Little[7c]), while rabbit sera do not show clear distinction between such dissimilar birds as chicken, pigeon and goose. Likewise Kodama[10], using this animal, demonstrated differences between the roes of fishes belonging to different families; these antisera however were not "species specific".

Summarizing the above widely different opinions one can only conclude that rabbits may be used as antibody producers with some measure of success in differentiating between different species of fish, but the animal most suitable can only be discovered by elimination. With this thought in mind, at some future date, it is planned to use as the antibody producer not only rabbits but also certain species of fish, e.g., cod and skate.

THE HALO COMPLEX OF APRIL 5, 1936, AT CHURCH POINT, N. S.

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(Received November 9, 1936).

ABSTRACT.

A halo complex occurred at Church Point, Nova Scotia, on April 5, 1936. In addition to the halos of 22° and 46°, the parhelia of 22°, the tangent arcs of the halo of 22°, the lower tangent arcs of the halo of 46° and the parhelic circle, oblique streaks were observed in various portions of the parhelic circle and also coloured arcs in the regions of the oblique arcs of the anthelion.

A very unusual combination of halos was observed at Church Point, N. S., on April 5, 1936. The phenomenon occurred at 11:15 a.m., A.S.T., and lasted "in parte" and "in toto" till 3 p.m. Figure I represents the outlines of the halos as observed a little before 2:30 p.m. when the altitude of the sun was 48°; aa′ represents the halo of 22°, bb′ the halo of 46°, cc′ the tangent arcs of the halo of 22°, ee′ the parhelia of 22°, mm′ the parhelic circle, ii′ the lower lateral tangent arcs of the halo of 46° and hh′ the horizon. As for rr′ the arcs observed seemed to correspond to the positions of the arcs known as the oblique arcs of the anthelion; but these arcs are generally referred to as being white arcs due to reflection by ice needles[1] and the arcs observed were coloured red on one side, thereby suggesting a case either of refraction or of diffraction. The parhelic circle was very conspicuous; a great portion of the circle consisted of white streaks much like the fibrous white clouds called cirri. Oblique streaks protending about 5° inside the circle and showing a red border towards the sun were also seen at the parhelia. Arcs aa′, bb′ and cc′ were coloured red towards the sun; the arcs ii′ and rr′ also were coloured red on one side but no reliable notes were made as to the relative positions of their coloured linings.

[1] Humphreys. *"Physics of the Air"*, McGraw-Hill Book Co., New York. **1929**, pp. 521-523.

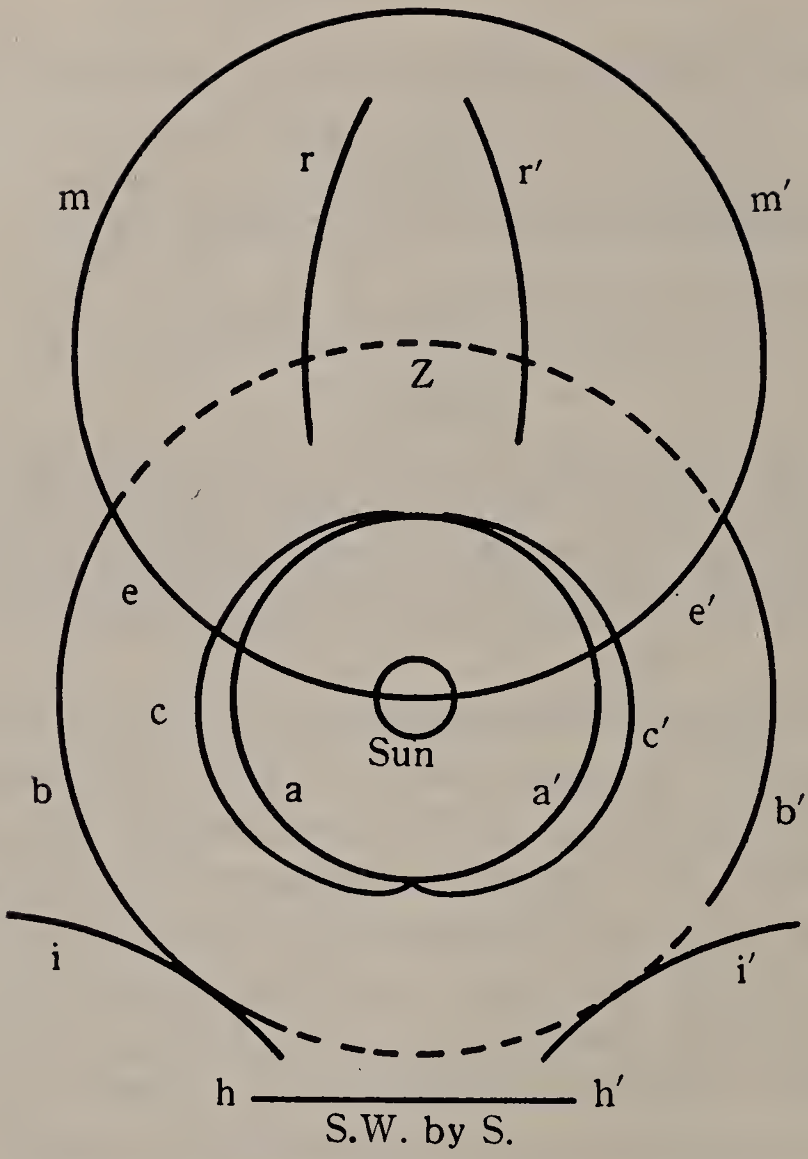

Fig. I. The Halo Complex of April 5th at Church Point, N. S. Dotted lines indicate portions of arcs that were not visible.

The arcs of 22° and 46°, also the parhelic circle, were measured with the sextant. The angular dimensions thus obtained exceeded the values obtained by calculation by a little more than one degree; but later this difference was found to be due to a deviation of the index mirror of the sextant used, the mirror being out of its position.

In conclusion, the writer wishes to stress the beauty of the phenomenon observed at Church Point, April 5, especially in the afternoon, after a little western breeze had cleared the atmosphere leaving a sky of a perfect blue except the glare around the sun, a few scattered cirri and the glorious halos. The temperature at that time of the day was 42°F.; on the following day it was much colder and on April 7, we had one of the worst storms of the season.

A SURVEY OF LAKE JESSE, NOVA SCOTIA.*

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(Received November 9, 1936).

ABSTRACT.

The results of a mid-summer survey of the physical and chemical conditions of the water and of the species comprising the flora and fauna of Lake Jesse, Nova Scotia, are presented. As indicated by the predominance of desmids in the phytoplankton, the waters belong to the Caledonian type.

This survey was made in connection with an experiment being carried out by the Fish Culture Branch of the Department of Fisheries, whereby copper sulphate was added to the waters of Lake Jesse on August 3, 1934, in an attempt to eradicate the competitor and predator fish of the brook trout. It is anticipated that a more suitable habitat in which to plant trout fry will thereby be created, after the food organisms, which were practically all destroyed by this procedure, have re-established themselves. Various phases of this experiment have already been described and discussed by Catt[1] and Smith[2].

This paper by no means presents a complete survey of Lake Jesse. It does, however, provide an index to physical and biological conditions which probably obtain in many small and similar lakes in the region, a region of Nova Scotia that has received no attention from a limnological viewpoint.

Lake Jesse covers an area of forty-five acres, and is situated at the head-waters of the Salmon river system, Yarmouth County, at latitude 44°2′0″ North and longitude 66°0′30″ West, and at an altitude of about 175 feet above sea-level. It lies in a formation of Precambrian quartzites and slates[3]. The maximum depth of water sounded in the lake was 6.6 metres, while the average depth was determined as 2.4 metres (May 30, 1929). The annual fluctuation in level of the water is not greater than 0.5 metre. There is one small inlet which, however, goes dry during the summer months (Fig. I). For the most part the bottom in the shallow water along the shores is composed of gravel and rubble; in the deeper water a soft organic ooze predominates.

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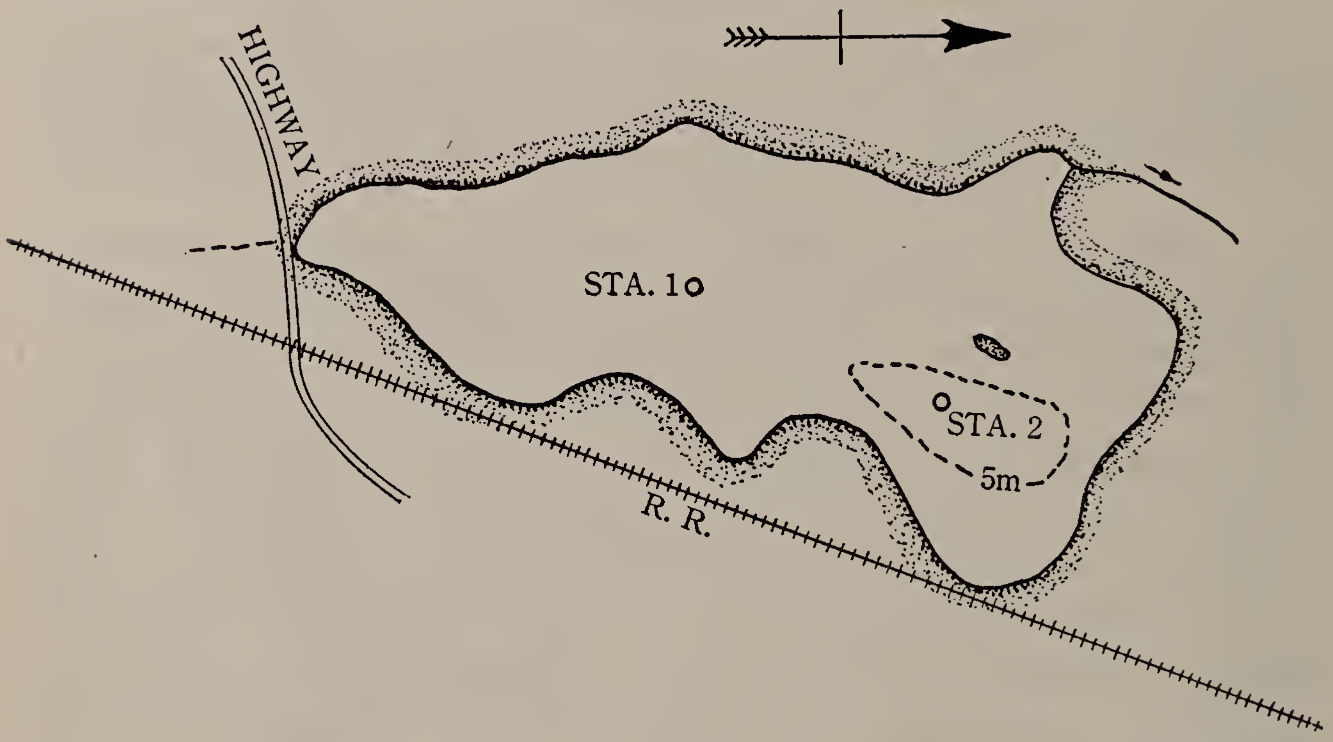
[1] Catt. *Trans. Amer. Fish. Soc.*, **64**, 276-280. (1934).

[2] M. W. Smith. *Trans. Amer. Fish. Soc.*, **65**, 101-114. (1935).

[3] Department of Mines, Canada. Geol. Surv., Map 39A.



Fiure I. Sketch Map of Lake Jesse.

Practically all of the data herein presented were secured by the writer from July 31 to August 8, 1934.

Hydrographic Data

Two stations were occupied, one at a depth of 4.0 metres, and another at 5.5 metres (Fig. I). The temperature, pH value, bicarbonate and dissolved oxygen content of the water were determined on a number of occasions. The data are presented in Table 1. The records for August 4 and 7 were made after the lake had been treated with copper sulphate, but apparently this treatment had little or no effect upon the factors involved.

Since the lake is not deep and there are no sudden depressions in the bottom contour, the waters are prone to overturn throughout the summer whenever subjected to a

TABLE 1

Physical and Chemical Conditions of Lake Jesse Water.

Date 1934	Temperature °C.			pH value		O$_2$, c.c./litre.		Bicarbonate, p.p.m.	
	Air	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
				Station 1, Depth 4.0 metres					
July 31	22.8	23.7	....	6.6	...	5.93	....	11.0	....
Aug. 1	19.9	22.3	21.4	6.5	6.3	6.04	5.83	10.0	9.9
2	23.3	23.5	21.4	6.5	6.3	6.38	5.53	10.1	10.6
3	18.9	21.8	21.8	...	...	....	....	....	....
4	22.1	23.2	21.9	6.3	6.3	7.40	6.22	10.7	10.0
				Station 2, Depth 5.5 metres.					
July 31		23.8	....	6.6	...	5.97	....	11.3	....
Aug. 1		22.5	21.0	6.5	6.2	6.06	5.62	10.2	10.0
2		24.0	21.1	6.5	6.2	6.17	5.66	9.8	9.5
4		23.5	21.4	6.3	6.3	6.81	5.66	10.4	9.9
7		22.6	20.6	6.4	6.3	5.83	5.08	10.6	9.9

strong wind. Thus on August 3, a day on which a steady southeasterly wind was blowing, the waters of the lake were found to be homothermous throughout (Station 1). According to Whipple's[4] classification of lakes, based on their temperature relationships, this type of lake belongs to the third order, in contrast to lakes of the first and second orders in which the difference between surface and bottom temperature is marked, and the waters are thermally stratified.

The dissolved oxygen content of the bottom waters was somewhat lower than that of the surface. This condition indicates decomposition taking place in the bottom deposits. The circulation of the water, however, would rarely permit much decrease in the dissolved ozygen content at the bottom. In such lakes where the bottom deposits contain decomposable organic materials, considerable diminution of the bottom oxygen content can, nevertheless, occur during periods of warm calm weather.

The waters of Lake Jesse are quite soft. The determined pH value ranged from 6.2 (bottom) to 6.6 (surface). The bicarbonate content was small, varying from 9.5 to 11.3 p.p.m.

FLORA

1. *Spermatophyta.*

Rooted emergent aquatics covered only a small area in the shallow water, most particularly at the south end of the lake and in coves at the northeast corner and at the outlet. We are indebted to Mr. E. W. Hart, Central Experimental Farm, Ottawa, for assistance in making the identifications of the following species:

Carex filiformis L.
Eleocharis palustris (L.) R. and S.
Sparganium eurycarpum Englm.
Eriocaulon articulatum (Huds.) Morong.
Pontederia cordata L.
Juncus acuminatus Michx.
Nymphaea advena Ait.
Castalia odorata (Ait) Woodville and Wood.
Lobelia dortmanna L.
Cicuta, sp.

[4] Whipple. *Amer. Nat.* **32**, 25-33. (1898).

2. *Algae.*

Eighty-three species of algae were specifically identified from the plankton taken on August 2. In addition there were representatives of the genera *Oedogonium, Spirogyra, Mougeotia* and *Zygnema,* which could not be determined owing to the absence of conjugating filaments. The identifications were kindly made by Professor C. W. Lowe, University of Manitoba.

This phytoplankton was characterized by an abundance of desmids. Of the eighty-three determined species of algae, fifty-one belonged to the Desmidaceae. This feature is not surprising when one considers the moderately low pH value and small bicarbonate content of the Lake Jesse waters, for it is in acid waters with little calcium that the desmids reach their best development. Considering the abundance of desmids, both in numbers and species, Lake Jesse may be assigned to the Caledonian type of lake, in which the phytoplankton is distinguished by a large desmid flora. This type is contrasted with the Baltic division with a predominance of Myxophyceae and Chlorococcales.

The following is a list of the planktonic algae:

MYXOPHYCEAE.

Chroococcales.

- *Chroococcus limneticus* Lemm.
- *Chroococcus turgidus* (Kütz.) Näg.
- *Aphanocapsa delicatissima* W. and G. S. West.
- *Microcystis aeruginosa* Kütz.
- *Merismopedia glauca* (Ehr.) Näg.
- *Coelosphaerium Kützingianum* Näg.

Hormogoniales.

- *Anabaena circinalis* (Kütz.) Rab.

HETEROKONTAE.

Heterococcales.

- *Botryococcus Braunii* Kütz.

CHRYSOPHYCEAE.

Chrysomonadales.

- *Dinobryon divergens* Imhof.
- *Dinobryon stipitatum* Stein.

Bacillarieae.

Centrales.
Melosira granulata (Ehr.) Ralfs.

Pennales.
Tabellaria fenestrata (Lyngb.) Kütz.
Tabellaria fenestrata (Lungb.) Kütz. var. *asterionelloides*, Grun.
Tabellaria flocculosa (Rothe) Kütz.
Synedra revaliensis Lemm.
Asterionella formosa Hass.
Pinnularia viridis (Nitzsch.) Ehr.
Frustulina rhomboides (Ehr.) De Toni.
Gyrosigma attenuatum (Kütz.) Cleve.
Surirella guatimalensis Ehr.
Surirella robusta Ehr.

Chlorophyceae.

Tetrasporales.
Gloeocystis gigas (Kütz.) Lagerh.
Sphaerocystis Schroeteri Chod.

Oedogoniales.
Oedogonium sp.

Chlorococcales.
Characium stipitatum (Bachmann) Wille.
Dictyosphaerium pulchellum Wood.
Pediastrum araneosum Racib.
Pediastrum araneosum.
  var. *rugulosum* (G. S. West) G. M. Smith.
Pediastrum Boryanum (Turp.) Menegh.
Pediastrum duplex Meyen.
Coelastrum microporum Näg.
Kirchneriella obesa (W. West) Schmidle.

Zygnemales.
Spirogyra sp.
Mougeotia sp.
Zygnema sp.

Desmidaceae.
Closterium Ralfsii Bréb.
  var. *hybridum* Raben.
Closterium didymoctocum Corda.
Closterium gracile Bréb.
Closterium intermedium Ralfs.
Closterium setaceum Ehr.
Netrium digitus (Ehr.) Itz. and Rothe.

Pleurotaenium Ehrenbergii (Bréb.) De Bary.
Pleurotaenium eugenium (Turn.) W. and G. S. West.
Triploceras gracile Bailey.
Triploceras verticillatum, Bailey.
Euastrum affine Ralfs.
Euastrum crassum (Bréb.) Kütz.
Euastrum didelta (Turp.) Ralfs.
Euastrum pinnatum Ralfs.
Micrasterias foliacea Bailey.
Micrasterias laticeps Nordst.
Micrasterias muricata (Bailey) Ralfs.
Micrasterias Nordstedtiana Wolle.
Micrasterias pinnatifida (Kütz.) Ralfs.
Micrasterias radiata Hass.
    var. *gracillimum* G. M. Smith.
Micrasterias radiosa Ralfs.
    var. *ornata* Nordst.
Micrasterias truncata (Corda) Bréb.
Cosmarium contractum Kirch.
Cosmarium subtumidium Nordst.
    var. *Klebsii* (Gutsw.) W. and G. S. West.
Xanthidium antilopaeum (Bréb.) Kütz.
Xanthidium antilopaeum (Bréb.) Kütz.
    var. *polymazon* Nordst.
Xanthidium armatum (Bréb.) Ralfs.
    var. *mediolaeve* G. M. Smith.
Xanthidium subhastiferum W. West.
    var. *Murrayi* W. and G. S. West.
    forma *triqueta* W. and G. S. West.
Xanthidium cristatum Bréb.
    var. *uncinatum* Bréb.
Arthrodesmus Incus (Bréb.) Hass.
Arthrodesmus triangularis Lagerh.
Staurastrum anatinum Cooke and Willis.
    var. *longibrachiatum* W. and G. S. West.
Staurastrum ankyroides Wolle.
Staurastrum arctiscon (Ehr.) Lund.
Staurastrum brevispinum Bréb.
Staurastrum brevispinum Bréb.
    var. *tumidum* G. M. Smith.
Staurastrum cerastes Lund.
Staurastrum grande Bulnh.
Staurastrum leptacanthum Nordst.
Staurastrum leptocladum Nordst.
Staurastrum megacanthum Lund.

Staurastrum Ophiura Lund.
Staurastrum punctulatum Bréb.
Staurastrum Wolleanum Butler.
Spondylosum planum (Wolle) W. and G. S. West.
Spondylosum pulchrum Arch.
Hyalotheca dissiliens (Smith) Bréb.
Hyalotheca mucosa (Dillw.) Ehr.
Desmidium Baileyi (Ralfs) Nordst.
Desmidium Grevellii (Kütz.) De Bary.
Gymnozyga moniliformis Ehr.

DINOPHYCEAE.
Peridinium cinctum Ehr.

FAUNA.

1. *Rotatoria.*

Of the planktonic rotifers, *Conochilus unicornis* Rouss. was the most abundant. *Notholca longispina* Kellic. and *Keratella* (*Anuraea*) *cochlearis* (Gosse) were common. *Polyarthra platyptera* Ehr. was represented by a few individuals, while *Rattulus rattus* (O.F.M.) was found only rarely. All except the last species are common constituents of limnetic plankton and are widely distributed.

2. *Hirudinea.*

Two species of leeches, *Macrobdella decora* (Say) Verrill and *Herpobdella punctata* (Leidy) were quite common. The identifications were made by Dr. R. J. Myers, Colgate University.

3. *Cladocera.*

Diaphanosoma brachyurum (Liéven), *Holopedium gibberum* Zaddach, *Daphnia pulex pulicaria* Forbes, *Daphnia longispina hyalina* Leydig (forma *galeata*), *Bosmina longirostris* (O. F. Müller) and *Leptodora kindtii* (Focke), usually found in plankton samples from lakes in the Maritimes and elsewhere, were common to abundant in Lake Jesse on July 31, and August 1 and 2. *Polyphemus pediculus* (Linné) was rare. The cosmopolitan *Chydorus sphaericus* (O. F. Müller) was also rare in the samples. The more typical littoral species, *Acantholeberis curvirostris* (O. F. Müller), *Alona affinis* (Leydig), *Rhyn-*

chotalona falcata (Sars) and *Alonella nana* (Baird) were found only in small numbers from hauls made in the shallow water.

4. *Copepoda.*

Epischura lacustris Forbes, *Diaptomus minutus* Lilljeborg and *Mesocyclops obsoletus* (Koch) were abundant in the open-water plankton. After the lake had been treated with copper sulphate *Eucyclops agilis* (Koch) (probably the limnetic variety *elegans* Herrick), along with *Diaptomus minutus*, were the first planktonic crustaceans to reoccur in moderate numbers. *Cyclops viridis* Jurine, *Eucyclops* prasinus (Fischer) and *Ectocyclops phaleratus* (Koch) were also encountered in small numbers.

5. *Amphipoda.*

The widely distributed *Hyalella knickerbockeri* (Bate) was common in the littoral zone.

6. *Hydracarina.*

Dr. Ruth Marshall, Rockford College, has identified the following species from the Lake Jesse plankton:

Arrhenurus elevatus Marshall.
Diplodontus despiciens (Müller).
Unionicola crassipes (Müller).
Neumania punctata Marshall.
Neumania extendens Marshall.
Neumania semicircularis Marshall.
Hydochoreutes ungulatus (Koch.).
Piona sp.
Megapes sp.

7. *Insecta.*

Limited collections were made of the insects and insect larvae. These collections were confined mostly to the shallow littoral zone.

Plecoptera (identified by Professor P. W. Claassen, Cornell University).
Acroneuria lycorias Newman.
Leuctra, sp.

Ephemerida (identified by Dr. F. Ide, University of Toronto).
Choroterpes basalis Banks.
Stenonema canadense Walk.

Odonata (identified by Dr. E. M. Walker, University of Toronto).
Gomphus exilis, Selys.
Hagenius brevistylus Selys.
Argia moesta putrida Hagen.

Hemiptera.
Represented by the genera *Ranatra, Gerris, Notonecta* and *Corixa* (*Callicorixa*).

Trichoptera (identified by Miss Jean Fraser, University of Toronto).
Represented by the families Sericostomatidae, (*Helicopsyche borealis* Hagen), Leptoceridae (*Oecetis*, sp.) and Limnophilidae.

Coleoptera (identified by Mr. W. J. Brown, Entomological Branch, Ottawa).
Gyrinus affinis Aube.
Macronychus glabratus Say.

8. *Mollusca.*

Professor F. C. Baker, University of Illinois, has identified the following species from Lake Jesse:

Campeloma decisum (Say).
Helisoma campanulatum (Say).
Helisoma anceps sayi F. C. Baker.
Amnicola limosa porata Say.
Gyraulus deflectens obliquus (DeKay).
Anodonta marginata Say.

9. *Batrachia.*

Triturus viridescens (Rafinesque) was present in small numbers. A few *Rana clamitans* Latreille, and presumably its immature stages, were also found. *Rana palustris* LeConte was noted at the outlet of the lake, and *Rana sylvatica* LeConte was common in the adjacent woods.

10. *Pisces.*

A preliminary note on the fish population of Lake Jesse, as revealed from the fish killed by the copper sulphate treatment, has already been presented by the writer[5]. The following is a list of the species that occurred in the lake:

Salvelinus fontinalis (Mitchill).
Notemigonus crysoleucas (Mitchill).
Semotilus atromaculatus (Mitchill).

[5] M. W. Smith. *Trans. Amer. Fish. Soc.*, 65, 297-299. (1935).

Catostomus commersonii (Lacépède).
Ameiurus nebulosus (LeSueur).
Anguilla rostrata LeSueur.
Fundulus diaphanus (LeSueur).
Perca flavescens (Mitchill).
Morone americana (Gmelin).
Pungitius pungitius (Linnaeus).

The writer is indebted to the Department of Fisheries for the opportunity of making the observations. The assistance of Mr. James Catt, District Supervisor of Fish Culture, St. John, is gratefully acknowledged.

EKMAN'S THEORY APPLIED TO WATER REPLACEMENTS ON THE SCOTIAN SHELF.*

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(Received March 15, 1937).

ABSTRACT.

A rough inverse correlation exists between excess S.W. wind mileage (S.W.—N.E.) at Sable Is. and September mean surface water temperatures in Halifax Harbour. In the absence of steep atmospheric pressure gradients over the neighboring ocean, to the south and west, in September 1934, a high correlation exists between the direction of the component winds (N.E. or S.W.) at Sable Is. and the daily mean surface water temperatures in Halifax Harbour. This indicates that wind, over suitable water areas, is an important factor in the phenomenon of replacement of coastal waters. Analyzed on the basis of the Ekman theory, N.E. winds over the Scotian gulf are favourable to the shoreward movement of offshore surface waters, while S.W. winds are favourable to offshoreward movement of surface waters with consequent upwelling. A modification of McEwen's application of Ekman's theory to upwelling indicates that waters of the "intermediate layer" are dissipated through coastal upwelling resulting from wind action. A quantitative estimate is made of the necessary enhancement of the "intermediate layer" to offset the loss due to upwelling. A southwesterly movement of approximately 0.6 nautical mi. /day (1.0 Km. /day) through a section (50 m. in depth and 60 Km. in width) normal to the coast is necessary to offset the loss through upwelling caused by an average monthly S.W. wind component of 7.0 mi. /hr. (11.3 Km. /hr.). The importance of the bottom configuration of the Scotian shelf to the circulation in a vertical section normal to the coast is indicated by the fixed condition ($d > 2D$) necessary for the establishment of the "surface", "mid water", and "bottom" currents. Generally speaking, depths greater than 150 m. (found chiefly within the margins of the Scotian gulf) are necessary for the establishment of such a system of currents on the Scotian shelf. Within the limited depths, the current system requires a period of approximately 3 days in order to attain 0.7 of its maximum efficiency.

Introduction.

Illustrations of water replacements on the Scotian shelf have been furnished in earlier papers[1]. In attempting to deal with the factors associated with the phenomenon, difficulty has always been encountered in attempting to distinguish between the effect of wind and that of a steep atmospheric pressure gradient. These replacements are more easily detected during the months of late summer as the waters are then more highly stratified. During late August and early September, it is usual for large scale replacements (in part associated with steep atmospheric pressure gradients over the neighboring ocean) to occur, and these are readily followed in an area such as Halifax Harbour.

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[1] Hachey, H. B. *J. Biol. Bd. Can.*, **1**, (4) 227-237. (1935). *Prog. Rep. (Atl.) Biol. Bd. Canad.*, **11**, 6-9. (1934).

Leim, A. H. and H. B. Hachey. *Trans. Amer. Fish. Soc.*, **65**, 279-283. (1935).

During the month of September 1934, the western North Atlantic, to the south and west, was comparatively free from storms[2]. A North Atlantic tropical cyclone was reported on the 5th of the month near the Bahama Islands. It ceased to be of importance after reaching Cape Hatteras on September 8th. About the middle of the month, a depression was noted to be moving northwestward, passing close to the Virgin Islands, but it seems never to have reached marked strength, and by the 21st, between the Bahamas and Bermuda, it ceased to be identifiable. Steep atmospheric pressure gradients over the western North Atlantic, to the south and west, were therefore relatively absent in September 1934. A large scale replacement of waters occurred[3] associated at first with the North Atlantic tropical cyclone of September 5th. The replacements continued for the greater part of the month. We may therefore look to an analysis of wind data, on the basis of Ekman's theory of wind driven currents[4], in an attempt to arrive at the possible relation of wind to this phenomenon of replacement.

The Effect of a Steady and Uniform Wind.

In Ekman's study of the influence of the earth's rotation on ocean currents, a most successful theory of wind driven currents was developed from a number of type problems which he solved by ordinary hydrodynamical methods. A particular problem was concerned with a steady and uniform wind blowing in a constant direction everywhere outside a straight and infinitely long coast, where the sea is considered to be of uniform depth. In such a case, a slope of the surface waters will arise, perpendicular to the coast, and gradually increase until the total flow, perpendicular to the coast, due to wind and pressure gradient, is zero.

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[2] Hunter, H. C. *Mon. Weather Rev.*, **62**, (9), p. 350. (1934).

[3] Leim, A. H. and H. B. Hachey. loc. cit.

[4] Ekman, V. W. *Arkiv. f. Matematik, Astron. och Fysik.*, **2**, 1-53. (1905-06).

The equation for a steady current under such conditions (density differences neglected) has been derived by Ekman, and he has shown that the character of the motion will depend upon the depth of the sea "d" compared to the depth of the wind current "D", and on the angle between the wind direction and the coast line. If the depth is sufficiently great (d > 2D) three currents will be present as follows:

(a) a surface current which will be a pure drift current deflected to the right of the wind's direction,

(b) a mid-water current parallel to the coast, and

(c) a bottom current moving more or less in a direction at right angles to the coast.

The bottom current is the bottom part of the gradient current and, in order to satisfy the condition of continuity, the flow towards or away from the coast in this layer must equal the flow away from or towards the coast in the surface layer. Thus in a cross section normal to the coast, the components of flow normal to the coast in the surface and bottom layers are productive of circulation as illustrated in Figures I (a) and I (b). In Figure I (a), a steady uniform wind (nor-

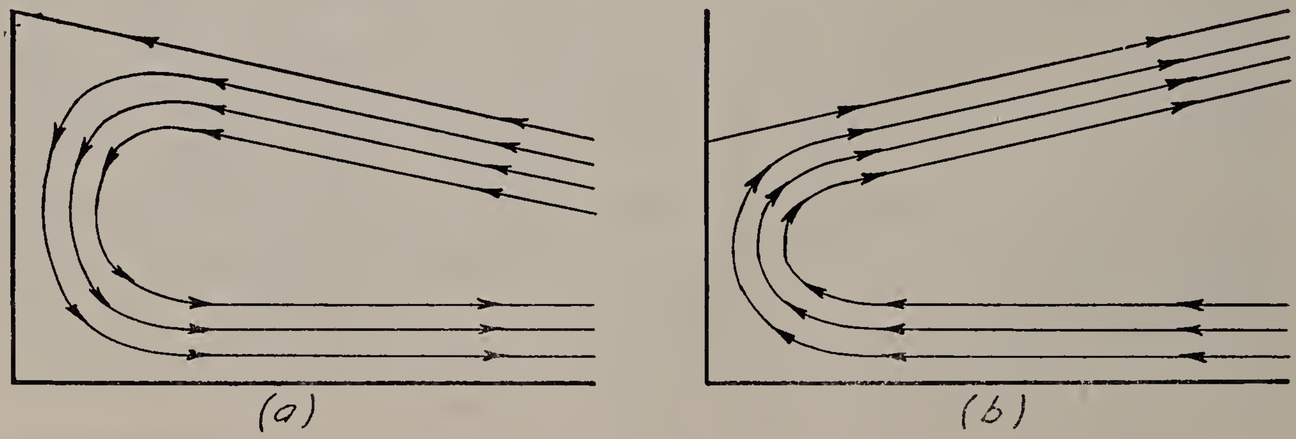

Figure I. Circulation in a section caused by a steady uniform wind, blowing in a constant direction everywhere, outside a straight and infinitely long coast (d>2D): (a) wind normal to the paper, towards the reader, (b) wind normal to the paper, away from the reader.

mal to the paper, towards the reader) blowing in a constant direction everywhere, outside a straight and infinitely long coast is causing a sinking of surface waters in the neighborhood of the coast, and thus a replacement of bottom waters by surface waters. In Figure I (b), the wind is represented as blowing in the opposite direction (normal to the paper and away from the reader). In such a case, the resultant vertical circulation is responsible for offshoreward movement of surface waters with consequent upwelling.

Theoretically, too, a wind of given strength would have its greatest effect when directed a little more than thirteen degrees to the left of the coast line, and perpendicular to this direction would have its smallest effect.

Application to the Scotian Shelf.

On the basis of the above exposition of the theoretical results of Ekman, winds most effective in setting up the illustrated system of currents are from the northeast where shoreward movements of surface waters are concerned, and from the southwest where offshoreward movements of surface waters are concerned. Our concern is not with local winds, but with those representative of conditions over the Scotian shelf. Hence, wind observations at Sable Is. furnish the most representative data available.

The Scotian shelf, with the exception of the Scotian gulf[5], consists of depths generally less than 100 m. The system of currents, illustrated in the diagram (Figure I), can be set up by the winds only where $d > 2D$. For a given latitude, D varies with the wind velocity according to the formula[6] $D = \frac{7.6}{\sqrt{\sin \varphi}} V_w$, where V_w is the wind velocity and φ is the latitude. For wind velocities between 5 and 10 mi./hr. (8 and 10 Km./hr.), in latitude 44° N, D has a value between 50 and 100 m. With such winds, the illustrated system of

[5] Hachey, H. B. *Trans. Amer. Fish. Soc.* (in press), **66**, (1936).

[6] McEwen, G. F. *Internat. Rev. d. ges. Hydrobiol. u. Hydrograph.* 243-285. (1912).

currents is possible where the depths range between 100 and 200 m. Such depths are found chiefly within the Scotian gulf.

The time required for such a system of currents to attain 0.7 of its final value is given by the formula[6]

$$t=\frac{d}{D \sin \varphi}+.0036 \frac{x^2 \sin \varphi}{D} \text{ days,}$$

where x is the distance from the coast in kilometres across the stream, and d and D are depths in metres. Giving x a value of 60 mi. (96 Km.), d a value of 150 m., D a value of 75 m., and solving we get t equal to 3 days. With these points in mind, our next interest is concerned with a method of detecting the reaction of the waters of the Scotian shelf to the wind.

The heat energy directly received from the sun is, of course, the most direct and important factor in the determination of surface water temperatures. An interchange of heat is continually taking place, and it is when this interchange is in favour of the surface waters that increasing surface water temperatures are recorded. During the period of increasing surface water temperatures, the process is modified considerably on the open coast through the upwelling of deeper and colder waters. As autumn approaches, the amount of heat absorbed by the surface waters is offset by the amount of heat lost, and the mean daily temperatures tend to vary but little from day to day. It is during this period that other factors, which tend to control the surface water temperatures, are most apparent. In particular, continued shoreward movement of warmer offshore waters on the Scotian shelf is readily detected by following the changing hydrographic conditions in Halifax Harbour. It can be readily shown that a rough inverse relationship (correlation coefficient more than twice the probable error) exists between excess southwest wind mileage (S.W.—N.E.) at Sable Is. and the September mean surface water temperature in Halifax Harbour. Wind records for Sable Is. (as furnished by the Meteorological Service of Canada) for the month of September have been analyzed for the years 1928 to 1936 inclusive (with the exception of 1932, when no records for the month were available). The wind mileages for the month were converted to N.E. and S.W. components, and differences (S.W.—N.E.) were plotted against the corresponding September mean surface water temperatures in Halifax Harbour. The result is indicated in Figure II.

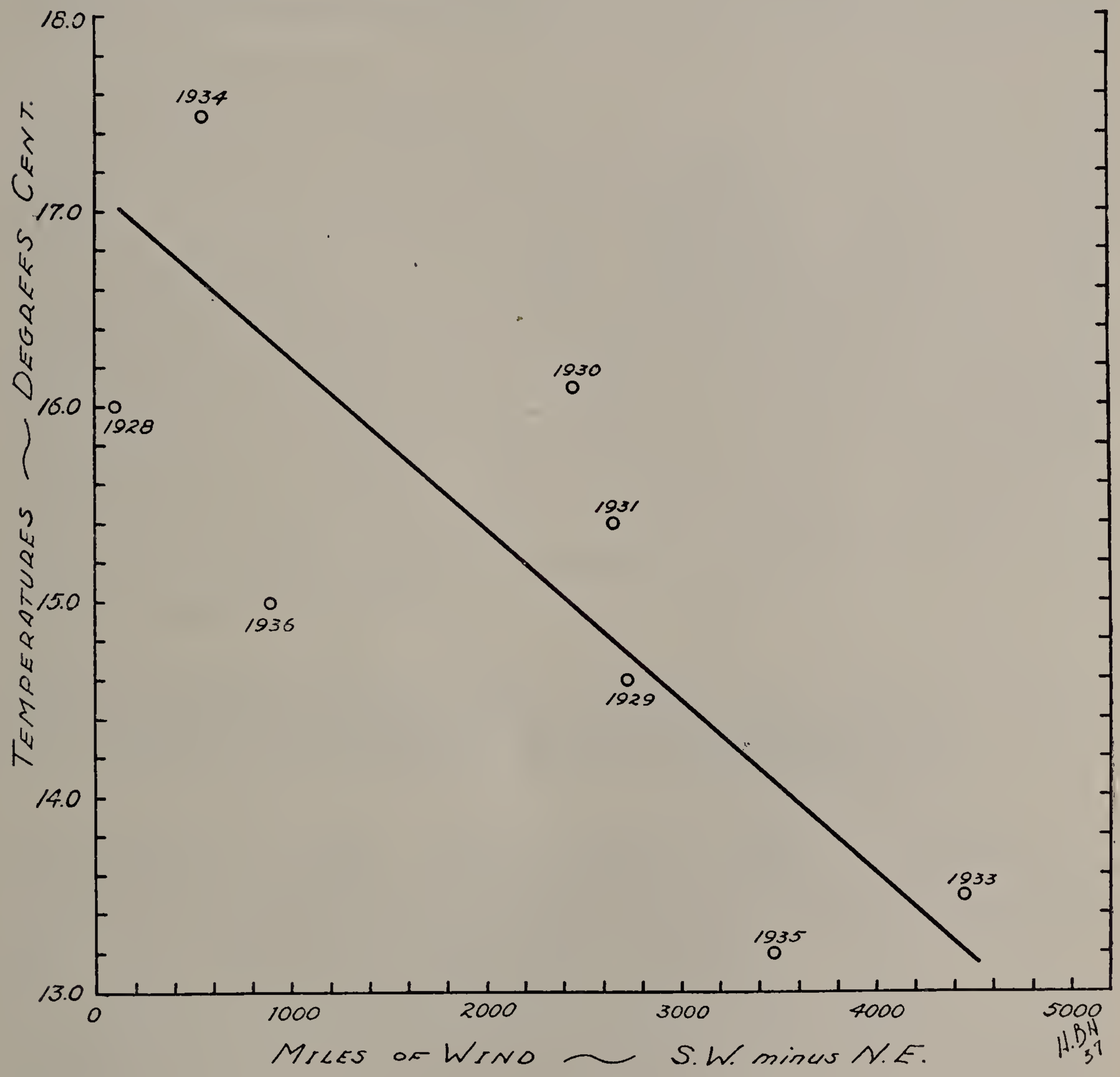

Figure II. S.W. minus N.E. component wind mileage for September at Sable Is. plotted against the corresponding September mean surface water temperatures in Halifax Harbour.

Further than this, the month of September 1934, with almost complete freedom from storms, offers an exceptional opportunity for a detailed examination of the relation between daily winds at Sable Is. and daily mean surface water temperatures in Halifax Harbour. The N.E. and S.W. components of the wind mileage at Sable Is. for September and part of October 1934 are plotted synoptically with the corresponding daily mean surface water temperature in Halifax Harbour in Figure III. According to the Ekman theory, N.E. winds would be favourable to onshore movements of surface waters within the Scotian gulf and this shoreward movement would be reflected in higher coastal surface water temperatures. Again, S.W. winds would be favourable to offshore movement of surface waters within the Scotian gulf resulting in upwelling which would favour lower coastal surface water temperatures. Keeping in mind the existence of a North Atlantic tropical cyclone during the first eight days of the month of September, the lag in the development of the circulation with respect to the wind, and the possibilities with respect to a North Atlantic tropical cyclone of short duration previous to September 21st, a very high correlation between wind direction and inshore surface water temperatures is indicated. The N.E. component winds of September 8th and 9th might be considered responsible for shoreward movements of surface

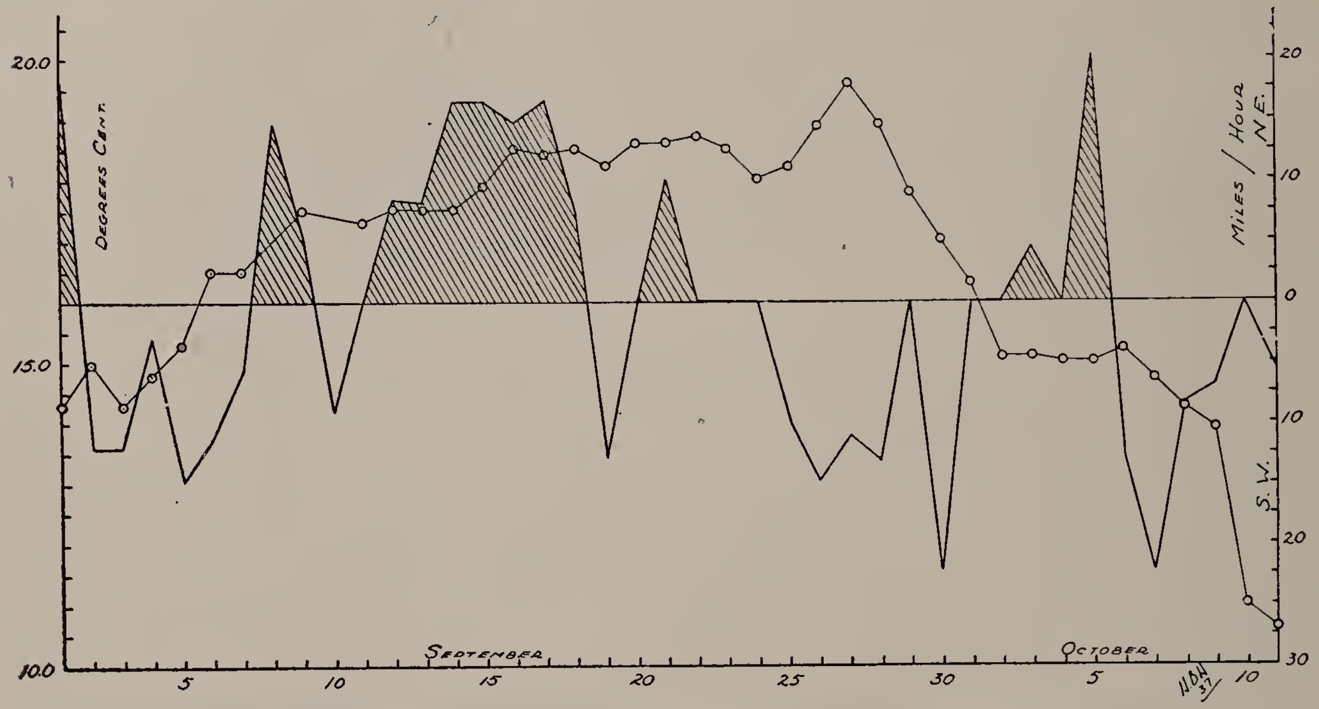

Figure III. Synoptic representation of N.E. and S.W. components of the wind mileage at Sable Is. for September and October 1934, and the corresponding daily mean surface water temperatures in Halifax Harbour.

waters bringing about an increase in the temperature of inshore surface waters. This increase in inshore surface water temperatures is followed by a slight drop as the winds moved into the S.W. Continued winds, with strong N.E. components from the 12th to the 18th inclusive, are probably responsible for a steady and considerable increase in temperatures. A change to the S.W. on the 19th is recorded by a slight drop in water temperature. S.W. components of the winds on the 21st and zero components on the 22nd, 23rd, and 24th may be correlated with the very slight temperature changes recorded. The rise in temperature from the 24th to the 27th does not seemingly follow from wind action and may possibly be related to the storm conditions previous to September 21st. Continued S.W. component winds are followed by a sharp and continued drop in temperature until October 2nd, when N.E. winds tend to hold the temperature at a steady level. After October 6th, a further drop in temperature is experienced until the normal temperature for the middle of October is reached (October monthly normal as determined for a ten year period is 12.0°C.).

Wind Action and Upwelling.

McEwen[7] successfully applied the theoretical considerations of Ekman to the problem of upwelling on the west coast of North America. The successful method of McEwen is considerably modified in formulating a temperature problem for the coastal waters of southern Nova Scotia. Some interesting theoretical results are obtained.

Hunter[8] states that, for August 1934, previous to the 24th of the month, no storm of any consequence was encountered in the waters to the south and west of Nova Scotia. A survey of these waters was made within the period August 8th to 12th inclusive. In particular, the western half of the survey was made on August 11th and 12th. The average S.W. component of the wind, as recorded on Sable Is. for the 8th,

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[7] McEwen, G. F. loc. cit.

[8] Hunter, H. C. *Mon. Weather Rev.*, **62**, (8), p. 302. (1934).

9th and 10th of August, was 11 mi./hr. (17.7 Km./hr.). The distribution of surface water temperatures is shown in Figure IV. Offshore surface water temperatures were about 17.0°C. while inshore temperatures ranged between 12.5°C. and 17.0°C. Over the western part of the area, the isotherm of 17.0°C. is, on the average, a distance of 40 nautical mi. (74.1 Km.) from the coast. Hence the horizontal temperature gradient of 4.5° occurs in a band of coastal water of an average width of 40 nautical mi. (74.1 Km.).

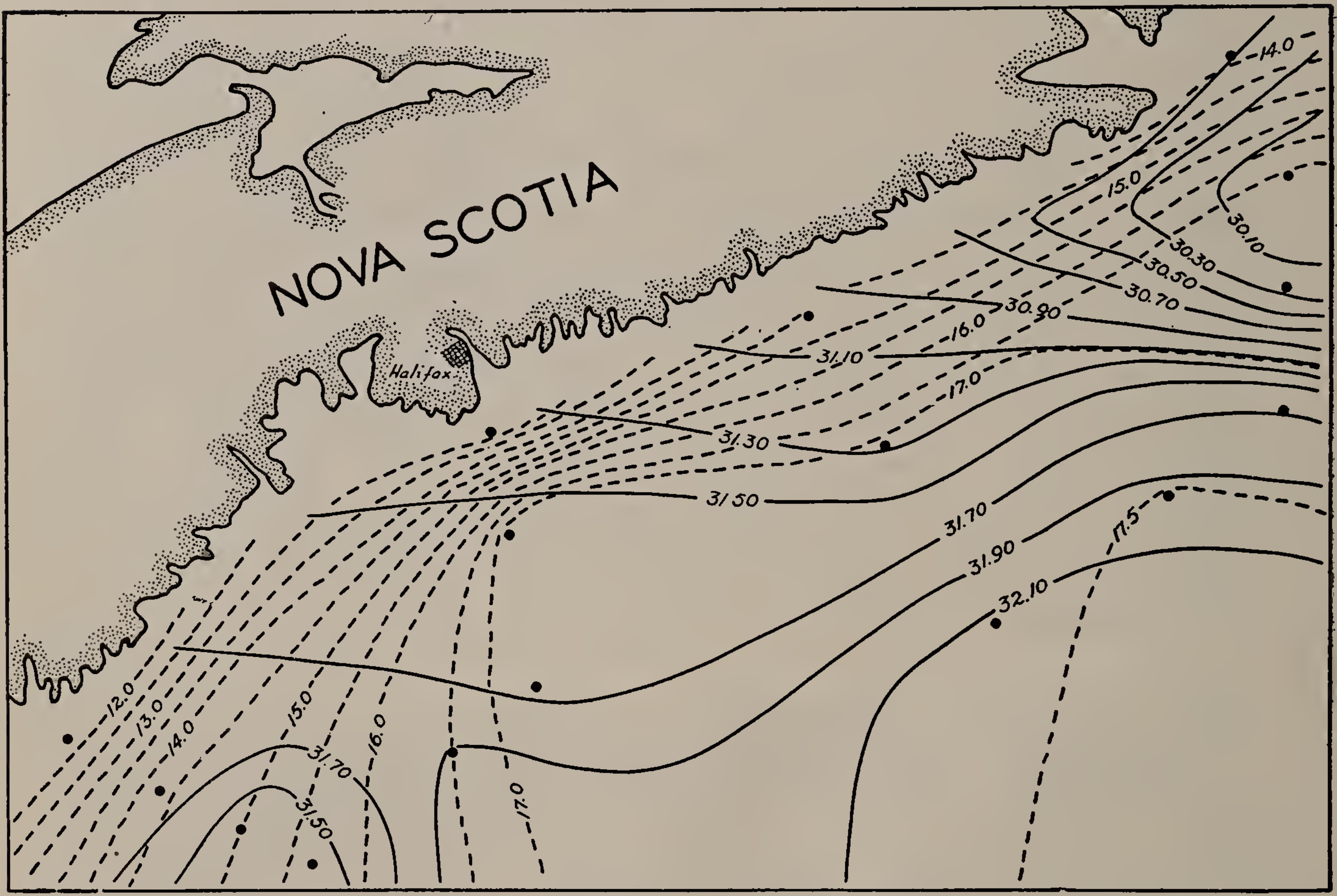

Figure IV. Distribution of surface temperatures and salinities on the Scotian shelf in August 1934. (Courtesy of the American Fisheries Society).

Let us assume that, if it were not for upwelling, the temperature of inshore surface waters for August 11th and 12th would be the same as that offshore (approx. 17.0°C.). Let us assume also that the lowered temperatures, following upwelling, are caused by the circulation set up by wind action, and that this causative wind is indicated by the average S.W. component as recorded at Sable Is. for the 8th, 9th and 10th of August. Let t be the mean temperature of offshore surface waters for the three day period, and let that mean be represented by the temperature observed on August 11th and 12th (approx. 17.0°C.). Let T be the corresponding mean temperature for inshore surface waters (12.5°C.). Let x_1 be the width of the band of coastal water in which the average horizontal temperature gradient of t-T exists, and let x_2 be the width of the band of offshore waters of a temperature t. Let the temperature be uniform to a depth y.

As compared to a similar volume of water at O°C., the volume represented by unit length of shore line, width x_1+x_2 and thickness y, has excess heat to the amount of

$$Ay\left\{\left(\frac{T+t}{2}\right)x_1 + tx_2\right\} \text{ units.}$$

Assume that this amount of heat is the same as if the total volume $y(x_1+x_2)$ was, to begin with, at a temperature t, and some volume xy at temperature t was removed from the region in the three day period (referred to above), and replaced by an equal volume xy upwelling from below at temperature t_1, and we have

$$Ay\left\{\left(\frac{T+t}{2}\right)x_1 + tx_2\right\} = Ay\,(x_1+x_2)\,t - Ayxt + Ayxt_1 \quad (1)$$

and symplifying we get

$$t-T=\frac{2x}{x_1}(t-t_1) \quad (2)$$

Where the temperature is uniform down to a depth of 5 m. and the depth of the wind current is taken as 75 m., McEwen[9] has shown that the amount of upwelling per unit length of coast line per unit time is

$$\frac{.02}{\sqrt{\sin\varphi}}V_w \quad (3)$$

where V_w is the wind component parallel to the coast in miles per hour, and φ is the latitude. Hence xy, the amount of upwelling in a three day period, is equal to the amount removed from the coast in the surface flow

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[9] McEwen, G. F. loc. cit.

$$= \frac{.02}{\sqrt{\sin \varphi}} V_w \times 3 \times 24 \times 3600$$

and therefore $$x = \frac{.02}{5\sqrt{\sin \varphi}} V_w \times 3 \times 24 \times 3600 \qquad (4)$$

where V_w is the average S.W. component of the wind for the three day period concerned (11 mi./hr. = 17.7 Km./hr.). Substituting for x in (2) and solving we get

$$t - T = \frac{2074\ V_w}{x_1 \sqrt{\sin \varphi}} (t - t_1) \qquad (5)$$

In the particular distribution of surface temperatures as obtained in August 1934, we have

$t = 17.0°$ C., $T = 12.5°$ C., $\varphi = 44°$ N., $x_1 = 73600$ m.

Solving (5) we get

t_1 (the temperature of the upwelling water) = 4.9°C.

For this region, such a result is a reasonable one, and indicates, on the basis of our assumptions, that the waters of the "intermediate layer[10]" are entering into this upwelling process. In August 1934 such temperatures were found inshore at depths greater than 25 m.

Discussion.

The preceding application of Ekman's theory to the waters of the Scotian shelf is possible only during those periods where wind action is the predominating cause of circulation in a vertical section normal to the coast. The typical circulation is brought about under certain stated ideal conditions which are only approximated to in the actual case. Particular attention must be given to the relationship between d (the depth of the water) and D (the depth of the wind current). It is formulated that the depth of the water must be, at least, twice that of the wind current. With the depth of the wind current taken as 75 m., it is postulated that the depth of the water necessary for the existence of circulation as illustrated in Figures I (a) and I (b) must be at least 150 m. Such depths are encountered on the Scotian shelf chiefly within the boundaries of the Scotian gulf[11]. Consequently, it might be expected that the most efficient system of circulation in a vertical section normal to the coast would be experienced, as a result of favourable wind action, in a section through the Scotian gulf and normal to the coast. When invasions of foreign waters[12] occur on the Scotian shelf and organisms typical of marginal waters are found within and about the margins of the Scotian gulf, the question is raised as to the reason for the limitation of the distribution within the area of the Scotian gulf. The above considerations of the circulation set up through wind action seemingly offer a reasonable answer to the question.

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[10] Hachey, H. B. *J. Biol. Bd. Can.*, **1**, (4), 227-237. (1935).

From equation (3) we may estimate the amount of upwelling U along the western half of the south coast of Nova Scotia (approximately 200 Km.), assuming that the circulation in a vertical section normal to the coast is efficiently produced by favourable winds. From (3) $U = \frac{.02}{\sqrt{\sin \varphi}} V_w$ per unit length of coast line per unit time. In September 1935, the average S.W. component of the wind was 7.0 mi./hr. (11.3 Km./hr.). Hence solving for U, we get the amount of upwelling along the western half of the south coast during the month of September 1935 (due to wind action only) as 9×10^{10} cu. m. It has been shown that the waters of the "intermediate layer" of the Scotian shelf enter into this upwelling. If the "intermediate layer" is to show no signs of diminishing as the season progresses, there must be sufficient enhancement to offset the amount of upwelling. Hence in a section normal to the coast, 50 m. in depth and 60 Km. in width, the enhancement necessary to offset the calculated upwelling for the month of September 1935 involves a movement through this vertical section of 3 x 10^4 metres per month or approximately 0.6 nautical mi./day (1.0 Km./day).

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[11] Hachey, H. B. *Trans. Amer. Fish. Soc.* (in press), **66**, (1936).

[12] Leim, A. H. and H. B. Hachey. loc. cit.

It is readily seen from theoretical considerations of the system of currents set up by winds that upwelling is favoured by winds from the southwest, and further that the "mid water" current tends to offset water movement from the northeast, which movement is necessary for enhancement of the "intermediate layer". Northeast winds tend to prevent upwelling by bringing about shoreward movements of surface waters. The "mid water" current would aid the enhancement of the "intermediate layer", and it is therefore probable that annual differences in the nature of the "intermediate layer" are related, in part, to the nature of the winds of the region.

The predominating wind during the summer months is from a general southwest direction. Hence, in summer, offshore movements of surface waters and onshore movements of bottom waters are favoured. The reverse is true in the winter months, when the predominating wind is from a northerly direction, favouring onshore movements of surface waters and offshore movements of bottom waters. Such movements of the bottom waters are attested to by the higher bottom salinities in the summer months (greater than 34.00‰ and as high as 34.90‰) as compared to the bottom salinities in the winter months (lower than 34.00‰).

RARE AND INTERESTING FISHES AND SALPS IN THE BAY OF FUNDY AND OFF NOVA SCOTIA.*

R. A. McKenzie and R. E. S. Homans.

Atlantic Biological Station, St. Andrews, N. B.

(Received July 3, 1937).

ABSTRACT.

This paper records the occurrence of seven marine fishes, one mass of marine fish eggs and two salps during recent years. The forms previously not reported from these waters are *Careproctus longipinnis,* and the eggs of *Anarhichas lupus.* Three of the other fishes are northern forms and two are southern. The occurrence of the salps is of interest to hydrographers.

Accurate records of the occurrence of species play a very important part in any investigation of distribution and it is our hope that the following records, whether indicative of ecological changes or not, may prove of use in the future.

Among the many marine organisms received in the Biological laboratory of the Fisheries Experimental Station, Halifax, for identification, the following have been considered worthy of recording:

FISHES.

Argentina silus Ascanius 1763. Argentine.

A specimen 14.7 cm. in length was taken from the stomach of a haddock captured April 15, 1936, southwest of Emerald Bank in 54 fathoms, Lat. 43° 05′N., Long. 62° 35′W. The bottom temperature was 3.2°C. Previous to this there have been only *two* positive records of captures off the Canadian Atlantic coast (correction to Vladykov and McKenzie[1], p. 59). The first, also from a fish stomach, was taken off Sable Island in 200 fathoms[2]. The second was taken on northeastern Banquereau in 1932[3].

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[1] Vladykov and McKenzie. *Proc. N. S. Inst. Sci.,* **19**, Pt. I, 17-113, 1934-35 (1935).

[2] Goode and Bean. "Oceanic Ichthyology". *Spec. Bull. U. S. Nat. Mus.* 1895, 553 pp.

[3] Thompson. *Rept. Nfld. Fish, Res. Comm.,* **2**, no. 1, 125-127 (1933).

Leptagonus decagonus (Black and Schneider) 1801. Northern Alligatorfish.

This specimen 22 cm. in length, undoubtedly one of the largest on record, was captured January 9, 1937, northwest of Sable Island, Lat. 44° 15′N., Long. 60° 55′W. in 50 fathoms, temperature 4°-5°C. It is a female, preserved in formalin, containing salmon pink eggs 1.0-1.5 mm. in diameter. Mr. J. Maher, radio operator on the S. T. Viernoe, who brought in this specimen, reported the capture of another taken on the same occasion. A week later, he reported seeing half a dozen on the deck of the trawler which was operating again in the same area. Mr. Maher's identification of the "half dozen" is undoubtedly correct since he named the original specimen when he brought it to this laboratory.

These captures of this Arctic form indicate a southward migration of considerable magnitude. Besides this, they represent the most southern capture on record of this species in the west Atlantic, even more so than the only previous record in Nova Scotian waters. This previous capture was a young specimen taken near the surface on the northeastern edge of Banquereau in 1932[3].

Neoliparis atlanticus Jordan and Evermann 1898. Common Sea Snail.

This specimen, 6.5 cm. in length, was taken by Clyde Tucker of the Atlantic Biological Station, from a small pool left by the receding tide in Brandy Cove, St. Andrews, N. B., on December 6, 1936. While considered to be fairly common in our waters, still, there are not many definite records of this species, and (to our knowledge) this is the first time it has been found in tide pools, though its European relatives are often found thus.

Careproctus longipinnis Burke 1912. Sea Tadpole.

This specimen, 10.9 cm. in length, was taken by the S. T. Viernoe, February 14, 1937, northwest of Middle Ground, Lat. 44° 47′N., Long. 60° 55′W. in 82 fathoms, bottom temperature 2.5°C. The ovaries of this specimen contain both small and large eggs, the latter measuring 3-4 mm. in diameter. This is the first (to our knowledge) of this northern species (Burke[4], p. 134) taken in Nova Scotian waters.

Remora remora (Linnaeus) 1758. Blue Sharksucker.

The only two previously recorded captures of this southern fish in these northern waters were reported by Vladykov[5] (p. 7); the one off Cape Sable, 1933, the other northwest of Sable Island, 1934. Our specimen was taken from a blue shark (*Prionace glauca*) August 13, 1936, on St. Pierre Bank, Lat. 45° 50′N., Long. 56° 0′W. This is the most northerly capture (to our knowledge) of this species ever recorded for the west Atlantic.

Anarhichas minor Olafsen 1774. Leopardfish.

This Arctic fish, while not uncommon in Nova Scotian waters, has been recorded but rarely. Bean[7] (p. 82) reported it in 1881 and Vladykov[5] (p. 3) in 1935. Bigelow and Schroeder[6] (p. 337) also mention the capture of three in January and five in March, 1934, on Sable Island Bank.

Our specimens are as follows:—three,—52, 91 and 134 cm., respectively, by the schooner Leah Beryl, February 19, 1937, in 51-90 fathoms, Lat. 43° 53′N., Long. 59° 05′W; one by the S. T. Rayon d'Or from Western Banks, April 9, 1937; and one, 130 cm., by the schooner Cachelot III, April 13, 1937, on Banquereau.

Anarhichas lupus Linnaeus 1758. Common Catfish.

To our knowledge, eggs of this species have not been recorded on this side of the Atlantic, though larvae have been captured at many points. On February 19, 1937, the S. T. Viernoe dragged up a mass of the eggs of this species. This loose mass of eggs just about filled a quart jar. The individual eggs ranged from 5.5-6.0 mm. in diameter. About three-quarters of the eggs had hatched, though the empty shells still remained attached to the mass. A large number

[4] Burke. *Bull. U. S. Nat. Mus.*, **150**, 204 pp. 1930.

[5] Vladykov. *Proc. N. S. Inst. Sci.*, **19**, Pt. I, 1-8, 1934-1935 (1935).

[6] Bigelow and Schroeder. *Bull. U. S. Bur. Fish*, **48**, 319-343, (1936).

[7] Bean. *Proc. U. S. Nat. Mus.*, **3**, 75-116 (1881).

of the remaining larvae, partially hatched (heads in, tails out of the shell), as well as the larger embryos, measured 17-18 mm. in length. This is at variance with Bigelow and Welsh[8] (p. 374) who state that the larvae are 12 mm. long at hatching. All of these possessed yolk sacs, some small, others quite large. Our specimens, for their size, have apparently very large yolk sacs also, when first hatched.

Histrio pictus (Cuvier and Valenciennes) 1837. Sargassum Fish.

This fish, while not taken in Nova Scotian waters, was taken outside the continental shelf off Nova Scotia and landed here. It was dipped at the surface about 400 miles southeast by south of Sable Island, Lat. 40°N., Long. 53°W., by the Cable Ship Cyrus Field, on August 1-8, 1935.

SALPS.

Salpa (*Jasis*) *zonaria* (Pallas 1774).

This form has a wide distribution in the North Atlantic. The following records of its occurrence are given here because it has been used as an indicator of water of "Gulf Stream" origin.

In 1932, this form was found in numbers off the central outer Nova Scotian coast. During 1933 and 1934, it was absent. However, late in 1935, immense quantities of both the solitary and the aggregated forms were found. Stomachs from haddock caught off Digby, Bay of Fundy, December 22, 1935, contained numbers of *S. zonaria*. The M. V. Zoarces obtained specimens in surface plankton tows and observed chains of the aggregated forms close inshore along the southwest (Cape Sable to Halifax) coast of Nova Scotia October 28—November 5, 1935. During October and November numerous specimens were obtained in and about Halifax Harbour. Mr. Noble Pye of Ecum Secum on November 4, 1935, brought a number of specimens of the same form to the Fisheries Experimental Station, stating that he had been using them as cod bait with a considerable degree of success. *S. zonaria* was also taken from the stomachs of haddock caught close to Sable Island, November 6, 1935. In 1936 (to our knowledge) this form was very rare in Nova Scotian waters.

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[8] Bigelow and Welsh. *Bull. U. S. Bur. Fish,* **40**, Pt. I, 567 pp. (1925).

Salpa vagina Tilesius (*S. tilesii* Cuvier) 1802.

This species, the largest of the Salps, occurs but rarely north of the Bahamas. Bigelow[9] (pp. 56 and 57) mentions finding this species off Lurcher Shoal, August 12, 1913, and in Massachusetts Bay in November and December, 1913. Huntsman[10] (p. 94) states that it was found south of Cape Cod in July 1913, and also about 135 miles southwest of Sable Island, July 21-29, 1915.

Thirteen specimens in the aggregated form were taken at the surface November 21, 1936, off Portuguese Cove, Halifax Harbour, by Ernest Purcell. This record extends the recorded distribution of this form in the west Atlantic somewhat farther north then previously.

We wish to express our thanks for checking our identifications of a number of the foregoing forms to the following:—Professor Victor Burke, Dr. A. G. Huntsman, Mr. J. T. Nichols and Mr. William C. Schroeder.

[9] Bigelow. *Bull. U. S. Bur. Fish.*, **40**, Pt. II, 1027 pp. (1928).

[10] Huntsman. *Contr. Can. Biol.*, **1918-20**, 93-97 (1921).

PRESIDENTIAL ADDRESS

Harry Piers.

(Read Oct. 14, 1936).

In opening another session of the Institute, I desire again to express deep appreciation of the greatly prized honour you have done me by twice electing me to the highest position in a society which has been very close to my heart ever since I was a lad forty-eight years ago. During all that period I have never missed a meeting except through illness or some such unavoidable cause.

As it has become customary for a president to fill the chair not more than two years, the present address is in the nature of a valedictory. I wish to thank the officers and other members for their hearty support, to wish my more worthy successor the best of luck and to bespeak for him such favours as I have enjoyed.

Deceased Members.

During the year we have lost one of our oldest life-members, Professor H. W. Smith, B.Sc., late of the Agricultural College, Truro, N. S., whose death occurred at Truemansburg, N. Y., last July. He was educated at Cornell University, came to the Normal School, Truro, about 1884, and later was on the staff of the Agricultural College. He joined this Institute as an associate-member on 6 Jan., 1890, and in 1900 became a life-member. He contributed three papers on fertilizers and crops to our meetings, one of which was published in the Transactions (see vol. 8, p. 122, 1891, and vol. 10, p. ix, 1901). It was probably with regard to his work connected with the foundation and growth of the Agricultural College that he mostly deserves recognition.

Progress of the Institute during the Past Session of 1935-6.

The past session was a successful and productive one. The annual business meeting was held on 9 Oct., 1935, and the full number of seven ordinary meetings from 4 Nov., 1935, to 4 May, 1936. These meetings were well attended for a provincial technical society, the average attendance being 21. The attendance of ladies has increased. A noticeable feature was the unusually full attendance at the council meetings. This indicates a lively interest, often at the sacrifice of convenience, which is gratifying.

At the seven ordinary meetings there were presented 20 papers by 24 authors, 5 of them being by joint authors. This is an average of about 3 papers at each meeting.

These papers may be grouped numerically under the following general subdivisions of natural science. All such subdivisions are noted in order that attention may thereby be drawn to the few branches which were not covered by some phase of research work: mathematics, 0; astronomy, 0; physics, 4; chemistry, 1; bio-chemistry, 1; geology, 0; palaeontology, 0; ethnology, 0; botany, 3; pathology, 2; embryology, 1; bryozoa, 1; fishes, 2 (zoology, total 6); chemical technology, 5.

These twenty papers gave evidence of painstaking research in the true scientific spirit, and will prove useful in advancing bit by bit our knowledge of these subjects.

From the standpoint of one interested generally in the fauna and flora of this region, subjects which some think should largely occupy the attention of a local society, important papers were: (a) Dr. V. D. Vladykov and R. A. McKenzie's excellent annotated list of the Marine Fishes of Nova Scotia, with keys for identification, notes on abundance, and illustrations of the various forms, which supersedes the marine section of J. M. Jones' List of 1879; and (b) Miss Margaret S. Brown's annotated list of the Mosses and Liverworts (Hepaticae) of Nova Scotia, in which are listed about 492 forms, including many which are new to this region. This greatly extends the somewhat meagre list compiled in 1876 by Dr. Lindsay from the collections of himself, Dr. A. H. MacKay, Dr. G. Lawson, and Dr. J. Somers. Dr. MacKay collected many forms after that period, but apparently did not publish the result.

The large number of useful papers on problems associated with the preservation of fish products is an evidence of the continued activity of the learned staff of the Fisheries Experimental Station at Halifax.

Not having yet seen the printed part of the Proceedings for the past session, I am unable to state how many of the before-mentioned papers are being published in full, and how many only presented in abstract, their publication taking place elsewhere.

Suggestions for Future Revisional Work in the Natural History Field.

With respect to the present need of thoroughly revised or new working-lists of our fauna and flora, it may be noted that in botany we still greatly require a revised list of our Nova Scotian plants, most of us having yet to refer to Dr. Lindsay's once-excellent list of sixty years ago, now out of print, and out of date as to the number of forms and the nomenclature.

At least we need a thorough revision of such perplexing local groups as our numerous Solidagoes (Golden-rods) and Asters, and possibly the Violets, groups which have been simplified by the work of recent systematists, but which are still extremely puzzling to a beginner when he has not at hand a modern local list which would minimize his labour. Local monographs on these groups, showing what forms we have, their abundance, and habitats, would be distinctly helpful to the many who take a general interest in our flora, as well as to specialists who are investigating the range of such plants. The northern location of Nova Scotia makes it important in regard to range and distribution, as it is a region where many southern forms pass out and boreal ones begin to be met with.

Very welcome monographic work may also be done on our Grasses and Sedges, as well as the Ferns, Lycopodinæ, Lichens and Algæ (exclusive of the Diatomaceæ, which MacKay has listed).

In zoology, many of the major groups, outside of our marine fishes, need revision in the light of recent additions as well as progress in nomenclature. This is a department to which the writer has long hoped to have time to make a contribution, by the compilation of many years' observations and records. The demands of routine work still, however, press heavily, and much that he would like to accomplish has regretfully to be deferred.

Most of the Invertebrata, with the exception of some popular groups, have hardly been touched, except as mentioned in Dr. Whitran's general list of the Marine Invertebrates of Canada. Here is a field for some one who will do the necessary collecting, and record the forms which occur here. The Invertebrates which have already received some attention are: the Fresh-water Sponges (by MacKay), Echinodermata (by Ganong), Mollusca (by Willis, Ganong and Campbell (?)), and some of the Insecta, such as the Orthoptera (by Piers), Neuroptera (?) (by Walker), Coleoptera (by Bethune (?) or Jones), Lepidoptera (by Jones, Silver, Russell, Perrin and others), and part of the Hymenoptera (Ants) (by Prest). From this we see how much is yet to be done in listing many of our lower forms of life, such as the Protozoa, Radiata, most of the Coelenterata, Articulata, Arachnida, Myriapoda, and many of the Insecta.

The 75th Anniversary of the Organization of the Institute.

As stated in my last presidential address, the present session is the seventy-fifth of this society, which is one of the most venerable of its kind in the Dominion.

The organization meeting took place on 31st December, 1862, and the first ordinary meeting on 19th January. The Institute was the successor of the N. S. Literary and Scientific Society of about 1859 to about 1862, of the very short-lived Halifax Literary and Scientific Association of about 1839-40, as well as of the still older Halifax Mechanics' Institute of 1831.

The three Canadian scientific societies which are older than our Institute are: (1) the Natural History Society of

Montreal, organized as long ago as 1827; (2) the (Royal) Canadian Institute, Toronto, 1849; and (3) the Hamilton Association for the Advancement of Science, 1857. Our neighbour, the Natural History Society of New Brunswick, Saint John, was also organized in 1862 and met till 1874, then became dormant, but was re-organized in 1880.

Of the original members of our Institute, several of whom I knew, not one is now living. The last survivor, that talented and lovable gentleman and great sportsman, Major-General Campbell Hardy, R.A., passed away at Dover, England, in 1919, whereby the last link which bound us with our inception was snapped. Those who succeeded the organizers have now mostly also departed, leaving us to carry on the torch and to see that what they accomplished by their freely-given work is not suffered to pass ungratefully into oblivion.

The Fiftieth Anniversary of the society (1862-1912) was marked by a commemorative meeting held on 20th January, 1913, at which the then recording-secretary presented a paper, prepared at the society's request, entitled "A Brief Historical Account of the Nova Scotian Institute of Science, and the events leading up to its establishment; with Biographical Sketches of its Deceased Presidents and other Prominent Members". This will be found in the Proceedings of the Institute, vol. 13, pt. 3, pp. lii-cxii.

It is for the society to now decide in just what form, if any, it would like to commemorate the passing of this further mile-stone in its career. I feel that you will agree that some really worth-while and appropriate recognition of the occasion should be made.

PROCEEDINGS OF MEETINGS

SESSION OF 1936-37.

(All ordinary meetings were held in the Medical Science Building, Halifax)

75th Annual Business Meeting, Oct. 14th, 1936. The annual address of the President was read by Harry Piers, Esq.

The Treasurer's Report showed that the receipts for the year amounted to $2,553.08; expenditures $1,857.59; leaving a bank balance of $683.82 plus cash on hand $11.67. The reserve fund consists of $72.18 in Dominion Savings, and $500.00 in Dominion of Canada 4% bonds. The Permanent Endowment consists of (a) Telephone Bonds, 6% to 1941, then 4% to 1966, $1,000.00, (b) Two Dominion of Canada Bonds 4½%, $1,000.00, (c) Dominion of Canada, 4%, $500.00.

The financial year was exceptionally demanding owing to (a) The Publication of a Catalogue of Scientific Periodicals, and clerical work incidental to this. Aided by a grant of $300 from the National Research Council and by the sale of the book the Institute has now recovered most of its outlay and further sales will soon show a profit; (b) The filling of gaps in the periodical files in the Library, for which purpose a net sum of $106.93 has been withdrawn from the Reserve Fund to be restored over a period of two years; (c) The publication of an exceptionally large and well illustrated number of the "Proceedings".

The Corresponding Secretary reported that during the past year 384 back copies of the "Proceedings" have been sent out. The "Catalogue of Scientific Periodicals of the Maritime Provinces", a cloth-bound volume of 82 pages has been printed and 80 copies sold.

The Librarian's Report showed that during the year 2,542 books and pamphlets have been received, bringing the total to 79,127. In addition to these there are in the Provincial Science Library (with which that of the Institute is incorporated) 20,269 books and pamphlets, and in the Hugh Fletcher Memorial Library (also incorporated) 425 books.

The Government grant of $500.00 has been continued and has been used for the purchase of books and for binding. During the year 842 books were borrowed, besides those consulted in the Library.

The Editor reported that the current number of the "Proceedings" was about to go to the printer.

New associate member announced (elected by Council Sept. 28); Dr. R. H. M'Gonigle.

Officers elected for 1936-37. *President*, G. H. Henderson, Ph.D.; *vice-presidents*, H. S. King, Ph.D.; R. J. Bean, M.S.; *treasurer*, D. J. Matheson, B.Sc.; *corresponding secretary*, Ernest Hess, Ph.D.; *recording secretary*, F. Ronald Hayes, Ph.D.; *librarian*, Harry Piers, Esq.; *members of the Council*, Donald Mainland, D.Sc.; C. C. Coffin, Ph.D.; Margaret R. Butler, Ph.D.; D. LeB. Cooper, Ph.D.; E. W. Todd, B.Sc.; Dixie Pelluet, Ph.D.; Harry Piers, Esq.; *auditors*, W. P. Copp, M.E.I.C.; S. G. Ritchie, D.M.D.; *nominees to the Government as members of the Provincial Science Library Commission*, G. H. Henderson, Ph.D.; Ernest Hess, Ph.D.

1*st Ordinary Meeting*, Nov. 9th, 1936. New members announced (elected by Council Oct. 26): ordinary member, Dr. C. B. Weld; associate member, Dr. A. C. Fales.

Papers: 1—A Survey of Lake Jesse, Nova Scotia, by M. W. Smith. 2—The Halo Complex of April 5th, 1936 at Church Point, N. S., by W. Haché. 3—Can Fresh Haddock Fillets Be Differentiated from Cod by the Precipitation Test? by G. A. McCurdy and V. D. Vladykov. 4—A Shell Disease in Lobster (*Homarus americanus*) Caused by Chitinivorous Bacteria, by Ernest Hess.

2*nd Ordinary Meeting*, Jan. 18th, 1937. New ordinary member announced (elected by Council Nov. 30); Dr. G. A. McCurdy.

Obituary:—The Institute learns with the deepest regret of the recent death in London, England, of its distinguished past-president, David F. Fraser-Harris, M.D.,D.Sc. (Lond.), F.R.SS.E. & C. He joined the Institute on 22nd Feb., 1912, ably filled the office of president from Oct. 1915 to Oct. 1918, and since his return to England has been a valued corresponding member. The Institute desires to tender to his widow and son its sympathy in their sad bereavement.

Obituary:—The Institute learns with deep regret of the death of Joseph Perrin of McNab's Island, Halifax, who, although not a member of the society, had contributed to its printed transactions two authoritative papers on the Lepidoptera of this region. The sympathy of the society is tendered to the members of his family.

Papers: 1—Electrolytes in Molluscan Blood and Muscle, by F. R. Hayes and D. Pelluet. 2—The Protective Layers of the Apple and their Development, by H. P. Bell. 3—Platinized Glass as a Laboratory Substitute for Massive Platinum, by C. C. Coffin.

75th Anniversary Meeting, School for the Blind, Halifax, N. S., Feb. 15th, 1937.

A public meeting was opened at 8.30 p.m. with an introductory address by the President. The estimated attendance was 250. The address of the evening was given by Major-General A. G. L. McNaughton, President National Research Council of Canada, who spoke on "The Organization of Research in Canada". After the meeting the President of the Institute entertained the members and their wives at a reception in his home, to meet General McNaughton informally.

3rd Ordinary Meeting, March 15th, 1937. New members announced (elected by Council Feb. 1): ordinary members, F. C. Collier, Esq.; Prof. B. A. Fletcher; student members, A. C. Topp, R. L. Cunningham, F. B. Maddock, J. L. M. Thurlow, W. F. Monovan.

Papers: 1—Ekman's Theory Applied to Water Replacements on the Scotian Shelf, by H. B. Hachey. 2—Seasonal Variations in *Chondrus crispus*, by Margaret R. Butler. 3—The Halo Method of Age Determination of Minerals, by W. J. Noble.

4th Ordinary Meeting, April 12th, 1937. New members announced (elected by Council April 5): ordinary member, Miss Evelyn M. Campbell; associate member, Mr. Norman E. Brown.

Papers: 1—Rare and Interesting Fishes and Salps in the Bay of Fundy and off Nova Scotia, by R. A. McKenzie and R. E. S. Homans. 2—The Deposition of the Halifax Series, by G. V. Douglas, R. L. Milner and J. MacLean. 3—On the Purine Metabolism of the Dalmatian Coach Hound, by E. G. Young, W. A. Crandall, C. F. Conway and J. Pottie.

5*th Ordinary Meeting,* May 3rd, 1937. New ordinary member announced (elected by Council April 26); Mr. G. A. Sandoz.

Papers: 1—The Effect of Molecular Structure on the Rate of Unimolecular Gas Reactions, by N. A. D. Parlee. 2—Equilibrium Moisture Content of Salt Fish Muscle, by D. LeB. Cooper. 3—Quantitative Changes in the Cytoplasmic Constituents of Developing Echinoderm Larvae, by D. Pelluet.

F. RONALD HAYES,
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

A SHELL DISEASE IN LOBSTER (*Homarus americanus*) CAUSED BY CHITINIVOROUS BACTERIA. Ernest Hess, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Nov. 9, 1936). Chitinivorous bacteria have been isolated from the affected parts of diseased lobsters from several regions of the Maritime Provinces. While such bacteria are fairly common in nature, no previous record of their ability to attack the chitin of living organisms can be found in the literature.

ELECTROLYTES IN MOLLUSCAN BLOOD AND MUSCLE. F. R. Hayes and D. Pelluet, Dept. of Zoology, Dalhousie Univ., Halifax, N. S. (Read Jan. 18, 1937). Estimates of Na, K, Ca, Mg, Cl, and SO_4 were made in the blood and muscle of the Octopus (*Eledone cirrosa*), the Scallop (*Pecten maximus*) and the whelk (*Buccinum undatum*). No characteristic differences were found between the forms investigated, although they represent three molluscan classes. Sea water and blood are similar in composition and the concentration of the six ions accounts for the isotonicity of the two media. Muscle differs from blood and sea water, being much higher in K, and lower in Na and Mg, while the total molar concentration of the six ions in muscle is scarcely two-thirds that of sea water. Muscle chloride is of the order of 10 percent of that in sea water.

THE PROTECTIVE LAYERS OF THE APPLE AND THEIR DEVELOPMENT. H. P. Bell, Dept. of Botany, Dalhousie Univ., Halifax, N. S. (Read Jan. 18, 1937). The protective layers of the developing apple are hairs, cuticle, epidermis and hypodermis. The development of these four layers is followed from the middle of May to the time of harvest. At first the chief protection is afforded by the layer of hairs, but these either disappear or become ineffective by the middle or end of June. The cuticle may be detected as early as the middle of May. By the first of June it is 1 to 2 microns thick. Its thickness increases steadily until by the middle of September it is 25 microns thick. During its development it penetrates the epidermal layer. The epidermis and hypodermis develop as follows: until the middle of June their cells are vitally active and accommodate themselves to the rapid enlargement of the apple by cell division in a tangential plane; from then on they become flattened, elongated tangentially and finally crushed. During these changes the cell walls in the hypodermis thicken and the cells become filled with a dense deposit.

PLATINIZED GLASS AS A LABORATORY SUBSTITUTE FOR MASSIVE PLATINUM. C. C. Coffin, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Jan. 18, 1937). Various substitutions of platinized glass for massive platinum in laboratory apparatus are discussed. Hydrogen electrodes, coulometer dishes, etc. are described.

SEASONAL VARIATIONS IN *Chondrus Crispus*. Margaret R. Butler, Dept. of Botany, Dalhousie Univ., Halifax, N. S. (Read March 15, 1937). The variations of ash, nitrogen and carbohydrate, in a series of monthly collections of *Chondrus crispus* from the same location, are compared with the variations in the carbohydrate complex extracted from them. Changes in the extracts are found to correspond with those of the whole plants. Therefore certain relationships which become apparent from a more detailed study of the extracts are taken as being expressive of those existing in the plant itself. From a study of the ratio of "ash sulphate to total sulphate" and of "carbohydrate to total sulphate" it is found that from January till May ethereal sulphates of the acid type predominate; while from May until October, the normal salts are in excess. From then until January there is a steady falling off in normal salts. The suggestion is therefore made that the acid type is a more permanent form, in the plant, and is metabolized only when the supply of normal salts is exhausted.

THE HALO METHOD OF AGE DETERMINATION OF MINERALS. W. J. Noble, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read March 15, 1937). The purpose of this work was to improve the accuracy of the halo method. A number of experiments were carried out to eliminate errors due to focusing and illumination and as a result some improvement in accuracy of age determination has been achieved.

THE DEPOSITION OF THE HALIFAX SERIES. G. Vibert Douglas, Robert L. Milner and John MacLean, Dept. of Geology, Dalhousie Univ., Halifax, N. S. (Read April 12, 1937). A description of the rocks of the Halifax Series with analysis of the two main types—slates and siltstones and the conditions under which it is thought these rocks were deposited. This theory was tested by a mathematical analysis of many measurements taken by the authors in the railway cutting.

ON THE PURINE METABOLISM OF THE DALMATIAN COACH HOUND. E. Gordon Young, W. A. Crandall, C. F. Conway and J. Pottie, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read April 12, 1937). The

Dalmatian Coach Hound has been subjected to metabolic experiment over the early period of growth to adolescence. Synthetic purine-free diets have been fed containing single proteins using casein as standard to contrast the excretion of uric acid and allantoin with the dietary content of particular amino acids. In addition a standard basal diet of meat proteins has been supplemented by pure amino acids and purines.

THE EFFECT OF MOLECULAR STRUCTURE ON THE RATE OF UNIMOLECULAR GAS REACTIONS. N. A. D. Parlee, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read May 3, 1937). The decomposition velocities of esters of the methylene diacetate series are sensitive to certain structural changes. The relative rates of esters made from aldehydes containing 1, 2, 4 and 7 carbon atoms are respectively 1, 13, 19 and 19. The replacement of H by Cl atoms results in a slight decrease in rate; the introduction of a double bond gives a fourfold increase. The effect of the double bond appears to be independent of the rest of the molecule. Thus crotonylidene furfurylidene and benzylidene diacetates react at the same rate at all temperatures.

EQUILIBRIUM MOISTURE CONTENT OF SALT FISH MUSCLE. D. LeB. Cooper, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read May 3, 1937). Some measurements of equilibrium moisture contents of salt fish muscle indicate that these values are independent of temperature within the range studied, and all values become indefinite near the vapour pressure over a saturated salt solution at the temperature investigated.

QUANTITATIVE CHANGES IN THE CYTOPLASMIC CONSTITUENTS OF DEVELOPING ECHINODERM LARVAE. D. Pelluet, Dept. of Zoology, Dalhousie Univ., Halifax, N. S. (Read May 3, 1937). An attempt is made to estimate the quantitative changes in the fat and mitochondra in unfertilized, fertilized eggs and early cleavages of Arbacia. Sections were cut 1 μ and the fat granules and mitochondra were counted by means of a squared ocular of known area, giving an estimate of the total number in the whole egg, whose volume has also been measured.

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An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review". A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, (7) **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76 (1927); C.A., **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts". In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**, vol. 4, pp. 625, 645.

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOL. XIX. 1937-1938 PART 4

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PROCEEDINGS
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Nova Scotian Institute of Science

SESSION OF 1937-1938
(Vol. XIX, Part IV)

THE BIRD LIFE OF THE GRAND MANAN ARCHIPELAGO.*

OLIN SEWALL PETTINGILL, JR.,
Carleton College, Northfield, Minnesota.

(Received November 29, 1937.)

ABSTRACT.

This paper is a survey of the bird life of the Grand Manan archipelago which lies in the Bay of Fundy in the Province of New Brunswick. To date 275 birds have been recorded in the region, of which 74 are known to breed. Twelve others are considered hypothetical. The material in this paper is presented under five headings as follows: (1) *Geography.* A general description of the surface of the archipelago, its people, climate and products. (2) *Ornithological Work.* A history of field studies from the time of John James Audubon's first visit. (3) *Acknowledgments.* (4) *Bird Life.* A discussion of the present and past distribution of birds, factors accounting for the changes in the distribution of birds since the time of Grand Manan's settlement, and noteworthy features of present-day bird life. (5) *Annotated List.* A systematic listing of all birds recorded in the archipelago with discussions pertaining to each form giving, if warranted, the status, migration dates, exceptional dates of occurrence, specimens taken, breeding data, census figures, taxonomic remarks, and historical notes.

GEOGRAPHY.

The Grand Manan archipelago lies directly adjacent to the northeastern coast of Maine at the mouth of the tide-famed Bay of Fundy. Although it is politically a part of New Brunswick, West Quoddy Head, Maine, is the nearest point of the mainland, being 5.79 miles across the intervening Grand Manan Channel through which passes the International Boundary Line.

The Grand Manan archipelago comprises a group of closely lying, rectilinear islands whose general trend is northeast and southwest, parallel to the mainland. These vary in size from small, slightly emerged ledges to the large island of Grand Manan which is 15.31 miles in greatest length and 6.70 miles in greatest width. The principal islands of the group, other than Grand Manan, are consecutively from north to south: Long Island, Nantucket Island, Big Duck Island, Ross Island, Cheney Island, White Head Island, Inner* and Outer Wood Island, and so-called Three Islands comprising Hay, Sheep and Kent's Island. These islands are all many times smaller than Grand Manan and are scattered off its eastern shore. The largest of these, White Head Island, is only two and one-half miles in length. The channel between any two of these islands is no greater than two and one-half miles and usually much less than a mile.

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* Contribution No. 5 from the Bowdoin Scientific Station, Kent's Island, Bay of Fundy, N. B.

Grand Manan, because of its comparatively large size, dominates the group. Its western frontage from Northern Head to Southern Head rises abruptly from Grand Manan Channel in impressive red-walled cliffs from 53 to 400 feet in height. Save for the fjordlike indentations of Money Cove, Dark Harbour, and Little Dark Harbour, the coastline is remarkably regular. The eastern shore is deeply cut by many coves and harbors. It is low and generally level with gravel beaches, tidal flats, and now and then a small bluff. In many places the sea has encroached upon the island's soil, leaving yellow, sharply hewn gravel banks. Back from the shore there are moundlike hills and poorly drained lowlands with sphagnum bogs and small, marshy ponds. The general terrain of Grand Manan rolls steadily upwards from the eastern shore until, along the middle of the island, the elevation of 250 to 400 feet is reached. This height is steadily maintained to the western cliffs, thus rendering this part more or less plateaulike and dissected only by stream-formed gulleys.

The central and western portions of Grand Manan are thickly wooded. Here the original growth of red and white spruce and fir still predominates in restricted areas where lumbering activities and fires have not yet penetrated; not far inland from Dark Harbour a little of this growth still stands in awesome proportions. Elsewhere there is a variety of gray, white and yellow birch, poplar, beech, maple, and an occasional white pine and red oak. In certain places the woods are wholly deciduous. Black spruce and alders are common along the sphagnum bogs which are themselves largely grown up with Labrador tea and other shrubs. Towards the edges of the great cliffs on the western coast and at Northern and Southern Heads—places severely exposed—the trees are thick and scrubby and almost wholly of spruce. Only the eastern portion of Grand Manan is humanly inhabited. Here are open, well-cultivated fields, pastures, orchards, and a frequent small woods of secondary growth. A grassy salt marsh with tidal channels and stagnant sloughs is located at Castalia. Extremely high tides usually inundate the area. Just inland from Whale Cove there is a small cat-tail marsh.

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* On the accompanying map Inner Wood Island is referred to as "Wood Island".

The present population of Grand Manan is approximately 2,500. While farming is indulged in, fishing is the main source of livelihood. Most of the dwellings are, therefore, centered about the fish smokehouses, the majority of which are located in the villages of Castalia, Woodward's Cove, Grand Harbour, and Seal Cove. North Head, the fifth village of the island, is largely a summer resort and is the chief port of entrance for visitors. Improved gravel roads connect the villages with one another, with Northern and Southern Heads, and with Dark Harbour.

The other principal islands of the archipelago are low-lying, the highest elevation of 74 feet being found near Prangle Point on White Head Island. Their terrains are small counterparts of Grand Manan itself, having precipitous bluffs, gravelly beaches, bogs, ponds and tidal flats. They are wooded primarily with spruce. Some of this natural growth has been cut away to provide for fish smokehouses and dwellings, navigation signals and fields for some agriculture and sheep grazing. The remaining woods are probably of virgin stand or old secondary stand and, except in the central portions of the islands, are characteristically scrubby.

The smaller islands of the archipelago range anywhere from emerged ledges capped with humus soil and herbaceous plants to bare ledges that appear only during low tides. Several of these islands, because they are somewhat apart from the archipelago and are, therefore, not included in the accompanying map, deserve special mention.

Gannet Rock is a small barren ledge seven miles southeast of Southern Head. The tall, black and white lighthouse constructed on its highest point is a familiar landmark.

The Murr Ledges extend four and one-half miles west from Gannet Rock and are separated from one another by broad channels. One of these, Yellow Murr Ledge, is sufficiently high above the high-tide mark to remain constantly above water.

Machias Seal Island with an adjoining ledge called Gull Rock is about ten miles to the southwest of Southern Head and slightly less distant from Cutler, Maine. A lighthouse and whistlehouse, two keepers' houses and other smaller accessory buildings are located on its fifteen-acre surface. These buildings are owned and operated by the Canadian Government. The island is treeless but there are several acres of grass-covered soil.

The summer climate of the Grand Manan archipelago is generally cool, the temperature averaging between 50° and 55°F. on the smaller islands and slightly higher on the main island. It is not unusual for the thermometer to drop below 45°F. during the night. The relative humidity is unusually high during June and July and dense fog sometimes persists for days, sometimes for weeks at a time. In the interior of Grand Manan the temperature rises occasionally to 85° or 90°F. Here it is more or less sheltered from the fog and cooling influences of the surrounding water. Elsewhere in the archipelago such temperatures are exceedingly rare. Winters are seldom severe and there is only a moderate amount of snow. At the Bowdoin Scientific Station on Kent's Island during the winter of 1936-37 the maximum temperatures recorded during December, January and February were 50°, 49°, and 46°F. respectively, while the minimum temperatures were 10°, 4.5° and 13.4°F. respectively. The archipelago is openly exposed to strong prevailing winds making the weather at times extremely disagreeable.

Ornithological Work.

Although the Grand Manan archipelago was first definitely settled at Grand Harbour in May, 1784, it did not spring into ornithological prominence until John James Audubon twice visited it while stopping over at Eastport during the first part of his Labrador journey in 1833. On the American revenue cutter "Swiftsure" he was first taken to Gull Cove, White Head Island, on May 22, where he was the guest of the island's owner, William Frankland. The greater part of his stay was occupied in studying the Herring Gull colony located on this island. He was greatly impressed with the way the gulls nested in trees and wrote of this in his "Ornithological Biography"[1]. Later on the revenue cutter's tender, the "Fancy", he was taken to the main island of Grand Manan.

In the early part of the summer of 1850 Dr. T. M. Brewer visited Grand Manan during his trip to the Maritime Provinces. Shortly thereafter he published a short list[2] and later included numerous random notes in "A History of North American Birds"[3-6], which he jointly published with Spencer Fullerton Baird and Robert Ridgway. Brewer visited the Grand Manan archipelago again in 1859.

From June 16 to July 8, 1856, Dr. Henry Bryant made an excursion to Grand Manan and Yarmouth, Nova Scotia, in company with J. E. Cabot. A. E. Verrill was on Grand Manan in 1859. Both Bryant and Verrill published lists[7-8] based on their respective trips. Spencer Fullerton Baird visited the Grand Manan archipelago in 1869 and 1872. He studied, among other things, the various shell-heaps and in a subsequent paper[9] discussed his work in the region. Charles J. Maynard came to Grand Manan in 1872. In his "The Birds of Eastern North America, etc."[10] he mentions seventeen species as occurring at Grand Manan.

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[1] Audubon, "*Ornithological Biography*", Adam and Charles Black, Edinburgh, 1835, vol. 3, xvi+638 pp.

[2] Brewer, *Boston Jour. Nat. Hist.*, 6, 297-308 (1852).

[3] Baird, Brewer and Ridgway, "*A History of North American Birds. Land Birds*", Little, Brown and Co., Boston, 1874, vol. 1, xxviii+596+vi pp.

[4] Baird, Brewer and Ridgway, "*A History of North American Birds. Land Birds*", Little, Brown and Co., Boston, 1874, vol. 2, 590+vi pp.

[5] Baird, Brewer and Ridgway, "*The Water Birds of North America*", Little, Brown and Co., Boston, 1884, vol. 1, xi+537 pp.

[6] Baird, Brewer and Ridgway, "*The Water Birds of North America*", Little, Brown and Co., Boston, 1884, vol. 2, 552 pp.

[7] Bryant, *Proc. Boston Soc. Nat. Hist.*, 6, 114-123 (1857).

[8] Verrill, *Proc. Boston Soc. Nat. Hist.*, 9, 233-234 (1863).

The first and only comprehensive list of birds for Grand Manan was published by Harold Herrick[11]. Containing 194 species it was based largely on observations obtained in two visits made to Grand Manan, one in May, 1871, and the other during June, July, and August, 1872.

R. F. Pearsall visited Grand Manan in the summers of 1877 and 1878 and afterwards published a few notes[12]. In the spring of 1877 the Bristol (Massachusetts) Ornithological Club made an excursion to Grand Manan. Three of its members, C. H. Andros, F. H. Carpenter, and E. A. Capen, gave various reports of different species observed in the "Ornithologist and Oologist". Everett Smith investigated the bird colonies on a number of the islands of the archipelago about 1882.

In 1891 Arthur Cleveland Bent and Owen Durfee arrived at Nantucket Island as guests of Simeon F. Cheney. Making their headquarters with him, they visited several of the surrounding islands. As a physical achievement their trip in a rowboat to Machias Seal Island on June 19 was the most notable. With the two sons of their host, Webster and Wilson, they left Nantucket Island at 4 a.m. and by hard rowing reached the island at 2 p.m. On the same day they returned reaching Two Island Harbour at 9 p. m.,—around trip approximating twenty-five miles! Bent and Durfee left the archipelago on June 22.

During the last half of the nineteenth century many rare birds in the Grand Manan archipelago were obtained by

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[9] Baird, *Proc. U. S. Nat. Mus.*, 4, 292-297 (1882).

[10] Maynard, "*The Birds of Eastern North America, etc.*", C. J. Maynard and Co., Newtonville (Mass.), 1881, iv+532 pp.

[11] Herrick, *Bull. Essex Inst.*, 5, 28-41 (1873).

[12] Pearsall, *Forest and Stream*, 13, 524-525 (1879).

George Augustus Boardman, for many years a resident of Calais, Maine. Although the St. Croix River Valley was his principal collecting ground, he welcomed specimens from the Grand Manan archipelago and the other islands on the west side of the Bay of Fundy. His collection was started soon after 1841 and was gradually augmented throughout his life. Being a man of some means, he solicited the services of many collectors, not only on the mainland, but on the Grand Manan archipelago as well. After Boardman's death in 1901 his entire collection was transferred to Fredericton, New Brunswick, where it was installed in the Parliament House.

Boardman published two important lists based on his collection. The first appeared in 1862[13] at the instigation of A. E. Verrill. By this time his collection had assumed significant proportions. The second was published in the "Calais Weekly Times" from November 23, 1899, to February 5, 1900. It was a revision of his old list to which many additions were made. Later it appeared together with much of his correspondence and natural history sketches in a privately published memorial volume edited by his nephew, Samuel Lane Boardman, and entitled "The Naturalist of the St. Croix"[14]. Many records of birds for the Grand Manan archipelago are contained in this volume. In the listing of rare birds, however, it is regrettable that such information as the numbers collected or observed, the sexes, the exact dates, and the specific localities are not stated, particularly since many of these birds are not only the first records for the area but also the only ones ever to be collected.

The name of Simeon F. Cheney appears not only in Bent and Durfee's account of their Grand Manan sojourn but in the accounts of many other ornithologists who came to Grand Manan during the latter part of the last century. It was he who aided Boardman and Herrick in securing many of their specimens. Cheney was apparently a well-informed student of birds, a "natural naturalist" according to Baird, and, although there are no ornithological observations published under his name, he sent migration notes to the Bureau of Biological Survey, Washington, D. C., and supplied many persons with important information.

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[13] Boardman, G. A., *Proc. Boston Soc. Nat. Hist.*, 9, 122-132 (1862).

[14] Boardman, S. L., "*The Naturalist of the St. Croix*", (privately printed) Bangor, 1903, xvi+351 pp.

Visitors to the Grand Manan archipelago in recent years have been Dr. Charles W. Townsend (July-August, 1923), Dr. F. A. Saunders (August 19-September 5, 1926), Francis H. Allen (August 14-27, 1929), Maj. Allan Brooks (September-October, 1930), James Bond of the Philadelphia Academy of Sciences (June, 1933), and J. J. Hickey (June, 1934). Machias Seal Island has been visited a number of times by Arthur H. Norton of the Portland Society of Natural History, his first trip being in 1902. Three representatives of the National Association of Audubon Societies have been to this island, namely, Dr. T. Gilbert Pearson (July, 1911), Robert P. Allen (June, 1931), and Allan D. Cruickshank (July 19-21, 1935).

In 1930 J. Sterling Rockefeller purchased Kent's Island and set it aside as a bird sanctuary. In the summer of that year, with his permission, Dr. Alfred O. Gross of Bowdoin College made a study of the American Eiders. In 1932, his son, W. A. O. Gross, began an investigation of the Leach's Petrel, the final results of which were recently published[15]. Dr. Ernst Mayr of the American Museum of Natural History visited Kent's Island from June 22 to July 5, 1933, to make a census of the bird life for Rockefeller and to study possible means for the conservation of bird life there. During this same summer Herman R. Sweet and Paul E. Floyd, two students just graduated from Bowdoin College, studied several species of land birds, Sweet specializing on the Black-poll Warbler. In 1934 four Bowdoin College students in connection with the Bowdoin-MacMillan Arctic Expedition spent the summer months on Kent's Island. These students, W. A. O. Gross, F. Burton Whitman, Jr., Paul G. Favour, Jr., and Frederick A. Fisher, Jr., were primarily interested in the

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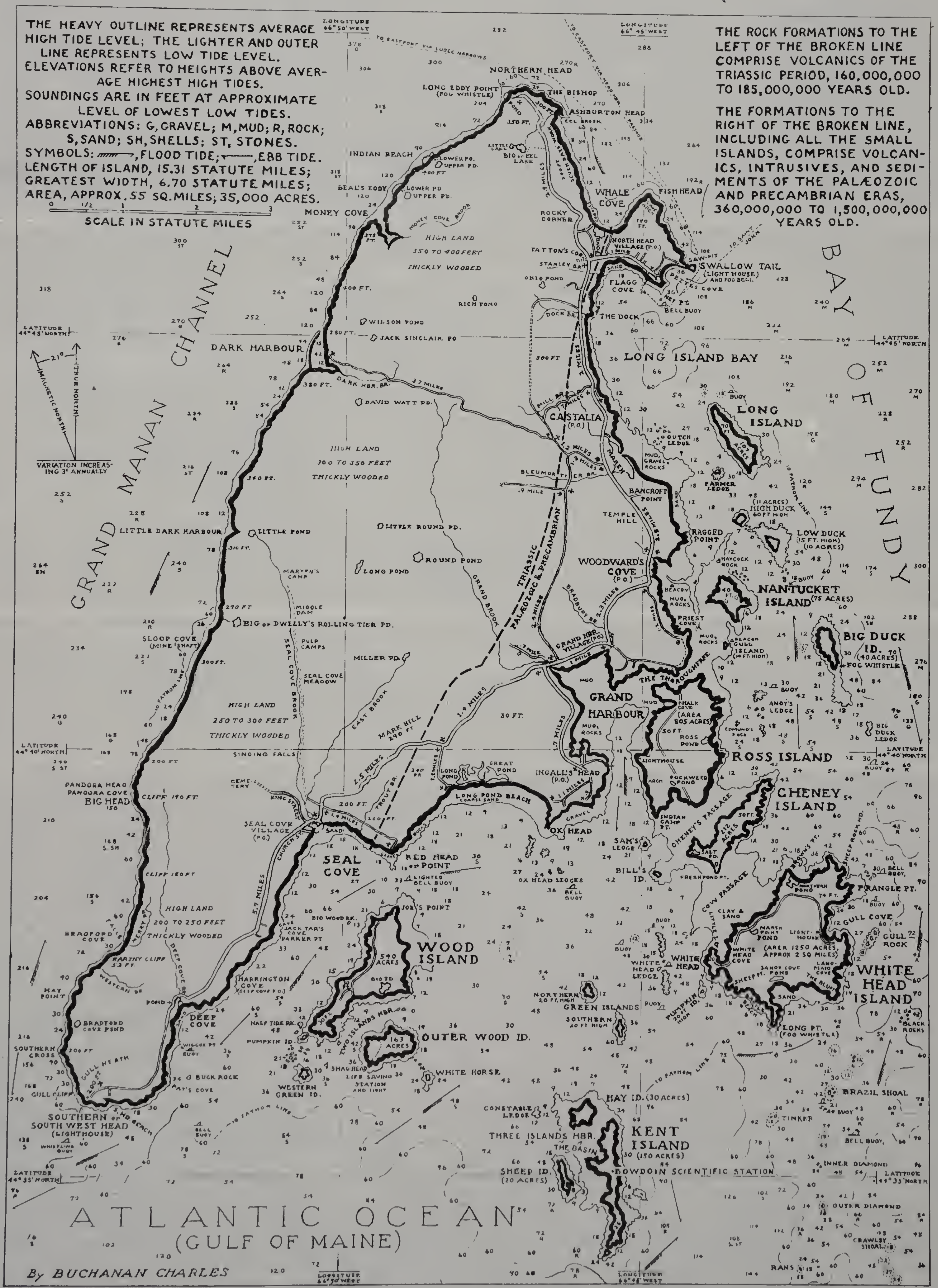
[5] Gross, W. A. O., *Auk*, 44, 479-493 (1935).



GRAND MANAN ARCHIPELAGO

Adapted from British Admiralty Chart No. 2539, United States Hydrographic Chart No. 1057, and Canadian Geological Survey Map No. 259A, with the addition of important data that have never before appeared on any map. Reproduced by permission of the Grand Manan Historical Society.

bird life of the island. Largely because of the great amount of enthusiasm shown by these students in their investigations together with the excellent results obtained, in 1935 Rockefeller presented the island as a gift to Bowdoin College for the establishment of a scientific station, believing that in this way the bird life of the island would not only be guaranteed protection but that it would also serve a very serious purpose. Eleven students, largely from Bowdoin College, established the Bowdoin Scientific Station that summer under W. A. O. Gross as director[16]. In 1936 and 1937 still larger groups of students were members of this station. Those individuals who devoted their time to ornithological work in 1936 were Latimer B. Hyde and Howard B. Miller.

In 1932 I visited Machias Seal Island with Edward F. Dana, staying there from July 8 to 15. Three years later I came to Grand Manan for the purposes of studying the bird life[17]. I arrived at North Head on May 31, bringing a car with me. I eventually established my base at Deep Cove and during the ensuing weeks worked from that location. My wife joined me on June 21. Mr. and Mrs. Edgar R. Russell with whom we stayed during our sojourn were most helpful in acquainting us with the out-of-the-way places of Grand Manan and in making us perfectly comfortable. Ross and Ronald Russell transported us in their boat to many of the outlying islands. We left Grand Manan on July 22. In 1936 I visited Kent's Island from July 30 to August 7 and in 1937 I carried on studies of the bird life of Machias Seal Island from July 2 to July 28.

In recent years no one person has contributed more to our knowledge of the birds of the Grand Manan archipelago than Allan L. Moses of North Head. A life-long resident of Grand Manan, much of his time has been devoted to the study of the local bird life. A skilled taxidermist, he has at North Head a small natural history museum in which are

[16] An account of the establishment of this Station is interestingly told by W. A. O. Gross in "Kent's Island—Outpost of Science" (*Nat. Hist.*, 37, 195-202 (1936)).

[17] A general report of my various activities and observations at Grand Manan in 1935 is given in my "Impressions of Grand Manan Bird Life" (*Wilson Bull.*, 48, 111-119 (1936)).

to be seen, handsomely mounted, a representative collection of birds of the region. Among them are specimens taken in the archipelago which were far beyond their normal ranges and which definitely confirm their occurrence here. While much of the data which he has acquired have been published elsewhere by persons to whom he has generously given them, he has published but three short ornithological accounts[18-20].

A review of the ornithological work accomplished in the archipelago would not approach completeness without mentioning the name of Ernest A. Joy who is at the present time the keeper of the Bowdoin Scientific Station. Like Moses, he has been a life-long resident of the archipelago and the fund of natural history knowledge which he has acquired during the years is readily apparent when he is engaged in conversation. He has been responsible for the collection of a number of rare specimens in Moses' collection.

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[18] Moses, *Jour. Maine Ornithol. Soc.*, 10, 90-91 (1908).
[19] Moses, *Jour. Maine Ornithol. Soc.*, 11, 12-15 (1909).
[20] Moses, *Jour. Maine Ornithol. Soc.*, 11, 24 (1909).

historical notes. Mr. Robie W. Tufts, Chief Migratory Bird Officer of the Maritime Provinces, and Mr. Hoyes Lloyd, Supervisor of Wild Life Protection, Department of the Interior, Canada, for various courtesies extended and for several important notes. Mr. F. Burton Whitman, Jr., for giving me access to his unpublished manuscript, "The Birds of Three Islands, New Brunswick", and permitting me to draw from it any records that I wished. Mr. Allan L. Moses for not only graciously allowing me to study the specimens in his museum at North Head and to publish the data, but also for his personal guidance to various parts of the archipelago of ornithological interest that I might otherwise have missed. Mr. Ernest A. Joy for giving me his daily records of birds kept from September, 1935, to July, 1937, while residing at the Bowdoin Scientific Station. Mr. Arthur H. Norton of the Portland Society of Natural History for many historical notes and comments and for critically reading this manuscript. Mr. Percy A. Taverner of the National Museum of Canada and Dr. Alfred O. Gross of Bowdoin College for perusing this manuscript and giving helpful suggestions and for the use of several of his excellent photographs.

Bird Life.

Generally speaking the Grand Manan archipelago lies in the Canadian Life Zone. In its forests where conifers still predominate are to be commonly found during the nesting season the Yellow-bellied Flycatcher, Acadian Chickadee, Red-breasted Nuthatch, Winter Wren, Hermit and Olive-backed Thrushes, Golden-crowned Kinglet, Bay-breasted, Black-poll, Magnolia, and Myrtle Warblers, Red and White-winged Crossbills, Slate-colored Junco, and White-throated Sparrow. The area, nevertheless, shows definite southern affinities by the presence, in the deciduous wooded portions and in the cultivated portions, of such Alleghanian forms as the Black-billed Cuckoo and Kingbird and the occasional presence of such forms as the Virginia Rail, Mourning Dove, Yellow-billed Cuckoo, Baltimore Oriole, and Field Sparrow.

In spite of the bird life being so strongly Canadian, certain kinds which belong to this zone, such as the Canada Jay and Spruce Partridge are, to the best of my knowledge, entirely absent, while the Goshawk, Arctic Three-toed Woodpecker, Tennessee, and Canada Warblers are apparently scarce.

The present distribution of land birds is probably quite different now from that found by Grand Manan's first settlers. Then, it may be logically assumed, the islands were almost continuously covered with rich growths of spruce and fir and contained birds strictly characteristic of the Canadian Zone. The changes gradually brought about by man in the cutting of the original "climax" growth created such new environments as open fields, pastures, orchards, villages, and woods of secondary growth. With these new environments came new bird associations. Birds *strongly* adapted to coniferous woods were forced either to areas where such an environment remained or from the islands altogether. To-day the Black-poll Warbler occurs only in the vicinities of scrub spruce on Grand Manan and the outlying islands. It is not "the most common warbler" noted by Herrick[11] (p. 31); instead the Black-throated Green Warbler is the most common warbler with the Redstart, Nashville Warbler, and Northern Yellow-throat running it close seconds. Furthermore, in the interior of Grand Manan, one finds common such birds as the Ovenbird, a species which Bryant[7] never mentioned and Herrick[11] (p. 31) considered quite rare. A few birds like the Winter Wren and White-throated Sparrow, whose spruce-covered habitat has been reduced, have readapted themselves, the former to the deep, deciduous woods, the latter to the "slash" areas in pastures. Other birds such as the Spruce Partridge and Canada Jay have found the remaining coniferous woods too restricted and have been unable to adapt themselves to a new environment, hence their disappearance. Along the roadsides and about the farms the Yellow Warbler and the Song Sparrow are common and the Chipping Sparrow rare. None of these birds were mentioned by Bryant[7] but Herrick found the Song Sparrow "rather uncommon"[11] (p. 32) and the Yellow Warbler "rare"[11] (p. 31). Open-country birds such as the Bobolink have included Grand Manan in their range but the grass-covered fields and meadows are large enough to support only a few of them.

Certain insectivorous birds are present on Grand Manan in enormous numbers. The abundance of swallows, though always to be expected in coastal regions, cannot escape one's notice. Their presence has, of course, been encouraged by the residents, both intentionally by setting up suitable houses for the Tree Swallows, and unintentionally by the peculiar construction of the fish smokehouses, thus allowing Barn Swallows many desirable nesting sites. Three species of flycatchers nest commonly on Grand Manan,—the Kingbird, Yellow-bellied and Alder Flycatchers. Three others, the Phoebe, Wood Pewee, and Olive-sided Flycatcher are to be seen from time to time. Many species of warblers are common. In 1935 there was not one locality in Grand Manan's interior where I could not hear at least one Black-throated Green Warbler singing.

The absence of a typical marsh community of Red-wings, rails, and bitterns is problematical. The plant associations in the marshes at Castalia, Whale Cove, and Big Pond seem capable of supporting at least a small assemblage; yet the Red-wing and Sora have never been found nesting, while the Virginia Rail has been found nesting once at Whale Cove Marsh and the American Bittern once at the Castalia Marshes.

During the breeding season hawks and owls seem to be comparatively few in the archipelago, only the Marsh Hawk being frequently seen. I observed the Sharp-shinned Hawk but twice and found one nest each of the Sparrow Hawk and Broad-winged Hawk. I did not see or hear an owl during my sojourn. From the records which Joy has acquired at Kent's Island, it appears that the archipelago lies well within the migration route of certain hawks and that they are fairly common during migration. In September, 1936, he noted a hawk 258 times as follows: Pigeon Hawk, 83; Sharp-shinned Hawk, 77; Sparrow Hawk, 60; Marsh Hawk, 31; Duck Hawk, 7. In the following month he saw a hawk 83 times as follows: Pigeon Hawk, 37; Sharp-shinned Hawk, 19; Marsh Hawk, 6; Sparrow Hawk, 4; Red-shouldered Hawk, 2; Broad-winged Hawk, 1.

The sea bird life of the Grand Manan archipelago is almost typically Sub-Arctic. The Yellow Murr Ledge is the southermost breeding ground of the Razor-billed Auk. The Atlantic Puffin nests in considerable numbers on Machias Seal Island; not more than a dozen pairs breed farther to the south at Matinicus Rock, Maine. The Black Guillemots and American Eiders are to be found nesting along the Maine coast but nowhere in the great numbers that are to be found from the archipelago northward.

The sea bird population has been subjected to many noteworthy changes since the archipelago was settled. An examination of early ornithological accounts shows quite clearly that either the Common or Double-crested Cormorant or both were breeding on Grand Manan, at least at Southern Head. On the main island, too, the Black Guillemot nested abundantly among the cliffs and the Herring Gull nested at Northern and Southern Heads, in the various bogs, and probably along its eastern and western shores. On the outlying spruce-covered islands such as White Head Island, Three Islands, Nantucket, and Outer and Inner Wood Islands Herring Gulls were likewise nesting. Some of the smaller treeless islands such as the White Horse and Western Green Island were the nesting grounds of the Arctic and Common Terns. Here they probably nested without the intrusion of the Herring Gull. Black Guillemots were scattered among these islands according to the availability of their particular type of nesting habitat. So far as it is known the Atlantic Puffin has always been confined to Machias Seal Island. The Razor-billed Auk, in addition to nesting on the Yellow Murr Ledge, may have nested commonly with the Puffins at Machias Seal Island. The fact that this species appears almost daily during the nesting season and has been known to nest once shows certain propensities for this locality. The

Gannets nested only on Gannet Rock while the Leach's Petrels and American Eiders were commonly distributed among the various islands.

The changes in the sea bird life of the Grand Manan archipelago have been brought about by the following known factors:

1. *General Encroachments of Civilization.*—The creation of villages, roads, farms, and lumbering activities on Grand Manan doubtlessly drove the Herring Gulls from the eastern shore, forcing them to nest only on Northern and Southern Heads and along the western shore. Likewise on the smaller islands which became inhabited, the Herring Gulls were forced to nest on certain portions not used by man. The erection of the lighthouse on Gannet Rock monopolized this small area and caused the disappearance of the Gannet; at Machias Seal Island a similar happening caused a reduction in the numbers of the Puffin and forced the Razor-billed Auk, a species more wary than the Puffin, to nest only at the Yellow Murr Ledge.

2. *Indians.*—While Grand Manan has no record of an Indian population, members of the Passamaquoddy tribe on the nearby mainland used to make frequent visits to the archipelago. The effect of their presence on the bird life is questionable. However, George H. Russell of the Grand Manan Historical Society and others tell of these Indians shooting sea birds for the millinery trade. The gulls, terns, and eiders were the chief victims. While their depredations caused a general reduction in numbers, it is doubtful if they caused any changes in the distribution of the sea birds among the islands.

3. *Egging.*—The taking of gulls' eggs for food has long been a custom of Grand Manan residents. In the early days the eggs were undoubtedly taken without any regulation whatsoever but it was not long before the residents effected a means of conserving this valuable asset. S. E. M. Smith[21] (pp. 55-56) writes of these regulations as applied to the out-

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[21] Smith, S. E. M., *Maine Nat.*, 2, 53-58 (1922).

lying islands, thus: "The gulls lay two, often three eggs, then incubation begins. The people have found by taking the first, the gulls can be made to lay again and again up to nine eggs. The last two or three they leave to the birds to be hatched and reared. This has been found to work out very well, with no inconvenience to the gulls, save a lengthening out of the breeding season. Something beneficial if anything, as the birds depend on the herring to rear their families; and no considerable numbers of herring are taken until early fall. Barrels of these eggs were preserved in water glass to last the entire year, thousands were sold fresh, as they are delicious for all purposes. This brought a fair revenue to the people. The way it worked out in practice was something like this: The islands were rented out by the day to parties coming from Grand Manan and other islands where no eggs are taken. These hunting parties began around 7 A.M., and hunted until 6 P.M. But it was understood the island owners were to have all the eggs they could find outside the hours specified. This work is carefully attended to, and frequently the net results for the owners was greater than the eggs taken by the parties paying well for the privilege." At the present time the gathering of eggs is permitted by the Canadian Government[22].

It is doubtful if egging during the past fifty years has caused any decrease in the numbers of the Herring Gull. Previous to that time it is probable that egging, coupled with two factors mentioned below, may have been of considerable importance. With the few enemies which the Herring Gull has to-day, it is unlikely that egging as now conducted can cause any serious reduction in numbers.

4. Foxes.—Foxes apparently never existed on Grand Manan until they were introduced at Southern Head in August, 1874, by the Pleasant Point Indians (a Passamaquoddy tribe) through the influence of W. B. McLaughlin (Copeland

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[22] The Canadian Department of the Interior has seen fit to grant under Section 20 of the Federal Regulations for the protection of Migratory Birds (Ottawa, 1937), permission to the owners or lessees of land of the Grand Manan archipelago to destroy gulls by taking their eggs as well as by shooting.

and Church[23], p. 125 and George H. Russell, *in litt.*, 1936). Thus isolated, the foxes multiplied and soon overran Grand Manan. The huge Herring Gull colony rapidly dwindled and, by 1883, it had disappeared. Further damage to the Herring Gull on some of the smaller islands is described by Andros[24] (p. 173) thus: "The distance to certain of the outlying islands is so short at ebb tide that the foxes have gained access to them, and thus not only have the ground breeders of the main suffered, but those on the pregnable islands, owing to the limited area, are depopulated to even a greater extent, and the former breeding grounds of the Ring necks [Semipalmated Plovers] are destroyed."

It seems plausible to me that this sudden change in the distribution of the Herring Gull caused by the foxes brought about indirectly the evacuation of the terns from all the islands but Machias Seal Island. The breeding Herring Gulls whose nests were continually broken up by the foxes were forced to seek new territories where the foxes would be less likely to intrude. Thus they resorted to the openly exposed, treeless islands where foxes would not remain any length of time and consequently usurped the breeding grounds of the terns. Records show that the terns were nesting in considerable numbers on the White Horse at about the time the Herring Gulls were being extirpated on Grand Manan and that the numbers apparently dwindled soon afterwards. Today the Herring Gulls have full possession of these islands, the terns last being recorded here in 1923.

5. Raccoons.—Raccoons were first introduced to Grand Manan about 1905. Like the foxes, these mammals reproduced rapidly. The Black Guillemots were undoubtedly subjected to their predation. Being capable of climbing down the steep cliffs, these mammals probably robbed the most inaccessible nests. While direct evidence of their actually preying upon the guillemots is lacking, it is significant that there have not been during the past thirty years the great

[23] Copeland and Church, *Proc. Biol. Soc. Wash.*, 19, 121-125 (1906).
[24] Andros, *Ornithol. and Ool.*, 12, 172-173 (1887).

numbers once reported. While there are flourishing colonies on Outer Wood Island and Kent's Island—places where these mammals have not been reported—the numbers of breeding birds remain decidedly few on Grand Manan where adequate nesting sites are proportionately more numerous. The raccoons are still very common on Grand Manan.

The absence of Leach's Petrels and Eider Ducks on Grand Manan may be attributed in part to the activities of both the foxes and raccoons.

6. *Avian Predators.*—At the present time the activities of avian predators are negligible insofar as they affect the nesting sea bird life. During my July sojourn at Machias Seal Island in 1937 not one hawk, owl, raven, or crow was observed. On the islands adjoining Grand Manan the Marsh Hawk is frequently observed. I have no evidence of its having molested the young of the gulls or eiders. The effect of these birds on past sea bird life is a matter of surmisal. If we may judge by the ornithological accounts, predatory birds have never been sufficiently numerous to be an outstanding factor in the decrease of sea bird life.

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To date 275 kinds of birds have been recorded in the archipelago, twelve others are considered of hypothetical occurrence. Due to the proximity of the mainland, none of the species or subspecies are at all peculiar to the region.

The following seventy-four birds have been definitely known to breed in the archipelago. Those marked with an asterisk (*) do not breed now.

Leach's Petrel.
*Gannet.
Great Blue Heron.
Black-crowned Night Heron.
American Bittern.
Black Duck.
Blue-winged Teal.
American Eider.
Sharp-shinned Hawk.
Bank Swallow.
Cliff Swallow.
Purple Martin.
Northern Raven.
Eastern Crow.
Black-capped Chickadee.
Acadian Chickadee.
Red-breasted Nuthatch
Brown Creeper.

Bald Eagle.
Marsh Hawk.
Osprey.
*Duck Hawk.
Eastern Sparrow Hawk.
Ruffed Grouse.
Virginia Rail.
*Semipalmated Plover.
American Woodcock.
Spotted Sandpiper.
Great Black-backed Gull.
Herring Gull.
Common Tern.
Arctic Tern.
Razor-billed Auk.
Black Guillemot.
Atlantic Puffin.
Black-billed Cuckoo.
Short-eared Owl.
Richardson's Owl.
Saw-whet Owl.
Belted Kingfisher.
Flicker.
Hairy Woodpecker.
Downy Woodpecker.
Yellow-bellied Flycatcher.
Alder Flycatcher.
Tree Swallow.
Eastern Winter Wren.
Eastern Robin.
Eastern Hermit Thrush.
Olive-backed Thrush.
Eastern Bluebird.
Eastern Golden-crowned Kinglet.
Cedar Waxwing.
Starling.
Red-eyed Vireo.
Eastern Yellow Warbler.
Magnolia Warbler.
Myrtle Warbler.
Black-throated Green Warbler.
Bay-breasted Warbler.
Black-poll Warbler.
Oven-bird.
Northern Yellow-throat.
American Redstart.
Bronzed Grackle.
Northern Pine Siskin.
American Goldfinch.
Savannah Sparrow.
Acadian Sparrow.
Slate-colored Junco.
White-throated Sparrow.
Lincoln's Sparrow.
Swamp Sparrow.
Song Sparrow.

The following thirty-six birds probably breed in the archipelago and definite records should be obtained.

Pied-billed Grebe.
Eastern Goshawk.
Sora.
Eastern Mourning Dove.
Yellow-billed Cuckoo.
Great Horned Owl.
Long-eared Owl.
Eastern Whip-poor-will.
Nighthawk.
Chimney Swift.
Ruby-throated Hummingbird.
Yellow-bellied Sapsucker.
Eastern Kingbird.
Blue-headed Vireo.
Black and White Warbler.
Nashville Warbler.
Northern Parula Warbler.
Cape May Warbler.
Black-throated Blue Warbler.
Blackburnian Warbler.
Chestnut-sided Warbler.
English Sparrow.
Bobolink.
Baltimore Oriole.
Scarlet Tanager.
Rose-breasted Grosbeak.

Eastern Phoebe.
Least Flycatcher.
Olive-sided Flycatcher.
Northern Blue Jay.
Catbird.
Indigo Bunting.
Eastern Purple Finch.
Red Crossbill.
White-winged Crossbill.
Eastern Chipping Sparrow.

Regular transients and visitants compose the remaining number of birds recorded in the archipelago. They make up more than half the total number of birds and account for the impressive length of the present list.

The presence of such a great number of regular transients is due to several factors. The Grand Manan archipelago is sufficiently near the coastline to be well within the common route of many birds undergoing migrations to and from their northern breeding grounds. The features of the island of Grand Manan are enough like those of the mainland to bring similar numbers of birds. Furthermore the rich and more isolated feeding grounds in the vicinities of the smaller, uninhabited islands bring added numbers of birds to stop temporarily or remain throughout the winter. There are, for instance, the salt flats and bars which are uncovered daily by the recession of the tides. Here shore birds gather in countless thousands to feed undisturbed. Fish abound in the surrounding waters for loons, grebes, cormorants, gannets, mergansers, and gulls. There is apparently ample aquatic vegetation for brant and sea ducks. There are the "tide-rips" where strong tidal currents rush over shoals, places that stir up organisms for enormous numbers of phalaropes.

The Grand Manan archipelago, on the other hand, is far enough from the mainland to be in the vicinity of such pelagic birds as the petrels and shearwaters. Many are attracted to the boats of the resident fishermen in search of bait and fish offal.

The presence of a great number of occasional and accidental visitants is the result of several factors. Being a group of sea islands, the archipelago is in a position to check southern sea birds driven northward by storms and hurricanes. The records of Black Skimmers acquired in 1879 were doubtlessly the result of a hurricane as were the birds noted along the New England coast at the same time (see Forbush[25], pp. xxi-xxiii). The archipelago, moreover, is sufficiently near the New England and New Brunswick coast to serve almost the same position as a peninsula for wandering bird life. For example, western birds undergoing abnormal easterly or northeasterly movements here come "to the end of land". Thus trapped, at least temporarily, their chances of being seen are many times greater than when they were passing along the continuous land masses. Records of the Arkansas Kingbird and Chestnut-collared Longspur and Lark Sparrows may be explained in this way. The Grand Manan archipelago is also sufficiently near the mainland to receive its share of such southern birds as the Little Blue Heron and American Egret which tend to wander northward after the breeding season.

The ornithologist who desires to observe some of the distinctive features of bird life in the Grand Manan archipelago is advised to visit the following localities:

1. Castalia Marshes.—A small colony of Acadian Sparrows is located here. It is easily reached from the Castalia-Woodward's Cove road.

2. Dark Harbour.—Almost anywhere in the woods along the stream entering this spectacular fjord can be found Yellow-bellied Flycatchers, Red-breasted Nuthatches, Winter Wrens, Red-eyed Vireos, Golden-crowned Kinglets, Black-throated Blue Warblers, Parula Warblers, Black-throated Green Warblers, Bay-breasted Warblers, Redstarts, and Oven-birds.

3. Deep Cove.—In the scrubby spruce growth west of the road running southward through Deep Cove Acadian Chickadees are as common as they are anywhere in the archipelago.

4. Southern Head.—Coupled with the extreme beauty of the high cliffs which drop down 200 feet into deep water and the strange rock formation called "The Southern Cross", are to be seen great numbers of the Black Guillemot, some of which undoubtedly nest in crevices of the cliffs. While there are nesting colonies of this bird which can be viewed to better advantage elsewhere in the archipelago, here the observer has an unusual opportunity to watch from a high elevation these birds diving, "flying" under water, and performing various courtship antics.

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[25] Forbush, "*Birds of Massachusetts and Other New England States*", Mass Dept. Agric., Boston, 1925, vol. 1, xxxi+481 pp.

5. *Kent's Island.*—Although many of the islands in the archipelago possess colonies of different species of sea birds, Kent's Island has the greatest variety. The largest Herring Gull colony is located here together with the largest number of breeding American Eiders. Also to be found nesting here are Leach's Petrels, Great Black-backed Gulls, Black Guillemots and Northern Ravens.

There is unquestionably no better locality to view the late summer shore bird migration than the so-called "Basin" at Kent's Island. A suitable small harbor and docking place at flood tide, at ebb tide this area becomes an extensively sheltered mud-flat across which flow several fresh-water streams draining the island's interior. Actually thousands of smaller shore birds concentrate here to feed. Along the open beaches of the island the larger shore birds such as the Hudsonian Curlew and Black-bellied Plover invariably gather.

Even though the Basin is periodically emptied of water when the tide recedes, a boat may always be moored in the sheltered deep water called "Three Island Harbour". A boat is perfectly safe here during the roughest of weather.

6. *Yellow Murr Ledge.* Among the crevices formed by the loose rocks on this ledge, there are to be found nests of a small colony of Razor-billed Auks. This is the only colony in the archipelago. Only in the very mildest of weather should a trip to this isolated islet be undertaken. Navigation is extremely dangerous as many of the ledges are just slightly submerged at certain tidal levels. There is no sheltered lee or cove and a boat has to be drawn up directly on the inclined portions of the ledge. A trip to the Yellow Murr Ledge is of added interest in the late summer as one is likely to see flocks

of phalaropes feeding in the "tide-rips" as well as a few petrels, shearwaters, and jaegars.

7. *Machias Seal Island.*—Although treeless there is here sufficient soil for the nesting burrows of many Leach's Petrels. Machias Seal Island not only possesses the only present-day colony of Common and Arctic Terns in the Grand Manan archipelago but it is further distinguished by having a colony of nesting Atlantic Puffins. Unfortunately a safe landing can be made here only when the water is moderately calm as the island is without a harbor and is openly exposed to the Bay of Fundy and Atlantic Ocean.

Annotated List.

The ensuing annotated list of birds known to occur in the Grand Manan archipelago[26] contains not only the forms which I have personally observed but also such forms as have been recorded in literature, such forms as are represented in Moses' collection, such forms as have been reported seen by others who have either visited the archipelago or are residents of it, and such forms as have been listed in unpublished notes and manuscripts.

Several explanations of the plan of the list are deemed necessary. The sequence of species and nomenclature follow in the main the "Check-List of North American Birds" (fourth edition, 1931) prepared by a Committee of the American Ornithologists' Union. Subspecific names have been used sparingly. In most cases this is because either a sufficient number of specimens have not been collected or examined critically for subspecific determination or because there is some question in the author's mind as to their validity. In the discussions pertaining to the majority of forms listed, the data have been arranged according to a definite plan. The first paragraph contains a statement of its present status. Here certain comparative terms are used to denote numerical status, these terms grading from "very abundant" to "accidental" in the following order: very abundant, abundant, very common, fairly common, common, uncommon, rare, very rare, casual, accidental. The remainder of the first paragraph contains, if available or warranted, such information as migration dates, exceptional dates of occurrence out of the normal seasons, specimens taken, etc. Separate paragraphs are used for breeding data, for census figures, for taxonomic remarks, and for historical notes. The above plan has been abandoned when a form is placed in the list on the basis of only one to three records; the data are merely given without further discussion. Forms considered "hypothetical" are those whose records for the archipelago are not satisfactorily verified by actual specimens collected or observed. Extinct birds recorded in the archipelago without specific information are held as hypothetical. No form deemed hypothetical is counted in the list.

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[26] There is some question whether Machias Seal Island is Canadian or American territory. In this paper it is held as geographically a part of the archipelago and its bird life is considered a part of the same region. Other persons may decide, if need be, whether the bird records established on this island and here incorporated are Canadian or American.

1. *Gavia immer immer* (Brünnich). Common Loon.

Fairly common transient and winter resident; frequently observed during the late spring and summer. On June 3, 1935, while inspecting the sea bird colony on Machias Seal Island, my attention was suddenly directed to an individual calling from the surface of the water not far from shore. Bent and Durfee saw one near Hay Island on June 16, 1891. Two were recorded by Whitman in the vicinity of the Yellow Murr Ledge on August 8, 1934. Saunders saw one at Grand Manan on August 19, 1926. Norton saw another a mile east of Machias Seal Island on August 27, 1936.

The assertion by Herrick[11] (p. 41) that the Common Loon does not breed on Grand Manan is undoubtedly true, there being no ponds sufficiently large for nesting habitats. Joy, however, noted one at intervals from April to October, 1901, on Big Pond near Seal Cove, though he found no evidence to indicate its breeding.

Gavia arctica pacifica (Lawrence). Pacific Loon.

Hypothetical. Herrick[11] (p. 41) included the Pacific Loon [="*C. arcticus* Black-throated Diver"] in his list, stating that it occurs in winter. Because he did not cite the source of his information, this western form is deleted from the present list.

2. *Gavia stellata* (Pontoppidan). Red-throated Loon.

Transient and, on the authority of Herrick[11] (p. 41), a winter resident. Moses and Joy have found it common at times in the outlying waters during the spring and fall. Moses took one male near North Head on October 26, 1908. Neither Moses nor Joy has ever recorded the Red-throated Loon during the winter months.

3. *Colymbus grisegena holboelli* (Reinhardt). Holboell's Grebe.

Fairly common transient and winter resident. Moses has two males in his collection from Pettes Cove, Grand Manan, one being taken on December 10, 1910, the other on April 1, 1916. Tufts[27] (p. 38) saw three birds in full breeding plumage along the shore of Kent's Island on April 16, 1926. Joy's earliest fall record is a bird seen at Kent's Island on October 8, 1935.

4. *Colymbus auritus* Linnaeus. Horned Grebe.

Common transient and winter resident. One male was taken by Moses at North Head on December 10, 1910; another at Nantucket Island on May 19, 1917. Joy saw his first fall Horned Grebe at Kent's Island on October 29, 1935.

5. *Podilymbus podiceps podiceps* (Linnaeus). Pied-billed Grebe.

Transient, apparently more common in the fall than in the spring; sometimes seen in the summer. In August, 1932, Joy saw one of these birds swimming and diving in the Basin at Kent's Island. Saunders observed one at Grand Manan on September 1, 1926.

It is possible that the species breeds among the rushes along the shores of Great and Long Ponds. Joy and Henry R. McLaughlin have noticed individuals on these ponds during the summer months.

6. *Thalassogeron chlororhynchos* (Gmelin). Yellow-nosed Albatross.

A record of the occurrence of this form normally inhabiting the oceans of the Southern Hemisphere was established by Joy when, on August 1, 1913, he shot a specimen six miles southeast of Machias Seal Island. Its sex was undetermined (Murphy[28], p. 58). The specimen was eventually secured by Dr. Leonard C. Sanford and now resides in the collection of the American Museum of Natural History.

7. *Puffinus griseus* (Gmelin). Sooty Shearwater.

Common visitant in summer and fall. Moses has in his museum at North Head a female taken near Grand Manan on July 19, 1922.

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[27] Tufts, *Canad. Field-Nat.*, 48, 38 (1934).
[28] Murphy, *Auk*, 39, 58-65 (1922).

On August 26, 1936, Norton secured an excellent view of one near the Yellow Murr Ledge. Later the same day he saw nine more about two miles from Gannet Rock.

8. *Puffinus gravis* (O'Reilly). Greater Shearwater.

Fairly common visitant in summer and fall. Moses has two specimens taken near White Head Island on October 18, 1921. One is a male and the other a female.

9. *Fulmarus glacialis* (Linnaeus). Atlantic Fulmar.

The statement by Herrick[11] (p. 40) that this bird occurs on the "fishing grounds in autumn" is supported by Moses who tells me that he has observed it several times in the outlying waters during the fall and winter. George A. Boardman (cf. S. L. Boardman[14], p. 192) wrote of having added this form [="Fulmar Petrel"] to his list of birds taken at Grand Manan.

10. *Oceanodroma leucorhoa leucorhoa* (Vieillot). Leach's Petrel.

Abundant during the late spring, summer, and early fall; breeds on many of the smaller islands. At Kent's Island Joy recorded the first petrel in 1936 on May 9, in 1937 on April 23. At Machias Seal Island Harvey E. Benson noted the first bird in 1937 on May 5.

During a visit to Machias Seal Island from July 8 to 15, 1932, I estimated approximately 2,000 pairs of Leach's Petrels to be nesting here. At this time the nesting season was well underway and fresh eggs were present in all the burrows examined. No young were found. Three years later I visited the island earlier in the season on June 3. At this time only a few newly made burrows were noticed although there were many places where they had just been started. Six completed burrows were examined but no eggs were present. According to Samuel E. Harvey, eggs are not commonly found in the Machias Seal Island colony until the third week of June. By the first week of August young are usually present. At Kent's Island W. A. O. Gross[15] (p. 385) saw no indications of petrels breeding until "the first or second week of June" and (p. 391) not until "the end of August" did most of the occupied burrows contain young.

Approximately 26,500 Leach's Petrels are believed to nest in the archipelago. These birds are distributed among the various islands as follows: Machias Seal Island, 2,000; Kent's Island, 10,000; Outer Wood Island, 12,000; Southern Green Island, 2,000; White Head Island, 500.

It is barely possible that there are a few isolated places on Grand Manan where Leach's Petrels nest. For instance, I heard this species calling as it flew above my camp at Deep Cove. This was late in the evening of July 19, 1935. Several days later while walking along the grassy crests of the cliffs at Wilcox Point, I came upon what appeared to be petrel burrows. The circumference of their openings, their courses through the soft soil, and their abrupt endings closely resembled the burrows on nearby Outer Wood Island. Yet the odor which is usually prevalent in occupied burrows was lacking, while an examination of a number of the burrows and a visit here late at night revealed no positive evidence of their nesting.

11. Hydrobates pelagicus (Linnaeus). Storm Petrel.

Verrill[8] (p. 234) listed one specimen from Grand Manan. Later George A. Boardman (cf. S. L. Boardman[14], p. 315) included this petrel in his newspaper list of birds of Maine and New Brunswick with the following statement: "Accidental; only Grand Manan".

12. Oceanites oceanicus (Kuhl). Wilson's Petrel.

Sporadically common visitant during the late spring and summer. Moses has found it more common in August. During the foggy weather of the early summer he has noted individuals within the harbors and coves of Grand Manan. Whitman recorded Wilson's Petrels a mile off Kent's Island on July 15, 1934. On July 18, 1937, an injured male bird was picked up at the base of the Machias Seal Island lighthouse. Severe bruises on the forehead gave fair indication that it had flown into the light the night before. I saw three birds which I determined to be of this species near Gannet Rock on July 20, 1935. Moses took a male specimen near Grand Manan on September 19, 1921.

13. Pelecanus erythrorhynchos Gmelin. White Pelican.

Herrick[11] (p. 39) wrote that a specimen "was taken some years since" in the Grand Manan area. This record of an accidental visitant, while more or less indefinite, does not seem extraordinary when taking into consideration the more satisfactory records for the nearby Maine Coast. (See Forbush[25], pp. 164-165).

14. Moris bassana (Linnaeus). Gannet.

Common transient in spring and fall; sometimes seen in the late spring and summer. Moses has a specimen taken by Joy at Inner Wood Island on June 4, 1901. Bent and Durfee saw two off the Yellow Murr Ledge on June 17, 1891. Joy observed four individuals several miles north of Machias Seal Island on August 2, 1935. Norton noted three "pre-nuptial" birds flying about just off the Yellow Murr Ledge on August 26, 1936.

While the Gannet does not nest in the archipelago at the present time, there was once a colony on Gannet Rock. Here it apparently thrived until the completion of the lighthouse which was lighted for the first time in 1831. From this time on, however, the colony apparently dwindled in numbers since the presence of the structure usurped much of its nesting area. According to Gurney[29] (pp. 311-312) only one or two pairs were found nesting by Verrill and Brewer in 1859 but the rock "was probably not entirely deserted until about 1866".

15. *Phalacrocorax carbo carbo* (Linnaeus). European Cormorant.

Apparently common transient and winter resident; does not breed. Moses has a female taken near Grand Manan on February 7, 1923. Tufts and Townsend[30] (p. 150) reported the above specimen as being shot at North Head and stated that a flock of "about two hundred" were wintering there.

Samuels[31] (p. 535) mentioned this species as breeding at Grand Manan. Later Bent[32] (p. 242) and Forbush[25] (p. 159) listed Grand Manan as a former breeding ground. The exact localities, however, were not named by these authorities. Audubon[33] (p. 486) spoke of seeing "thousands of Gulls and Cormorants" as his party approached the northern end of Grand Manan. It may well have been that this portion of the archipelago was a nesting ground of this form.

16. *Phalacrocorax auritus auritus* (Lesson). Double-crested Cormorant.

Common transient and summer visitant; does not nest. This form breeds on a few of the islands close to the nearby western mainland, which accounts in a large measure for the occurrence of the bird here during the summer months. I saw one near the shore at Deep Cove on June 7, 1935. During July, 1937, individuals and small flocks were seen almost daily at Machias Seal Island. Allen noticed a flock of seventeen flying south over Grand Manan on August 23, 1929. Saunders observed many of these birds between August 19 and September 5, 1926.

17. *Ardea herodias herodias* Linnaeus. Great Blue Heron.

Fairly common summer resident; undoubtedly nests. Almost invariably I observed a Great Blue Heron during visits made to the Castalia Marshes. Saunders listed it as seen "daily", Allen as seen "frequently". Members of the Bowdoin Scientific Station noticed a Great Blue Heron at Three Islands on August 1, 1936, and Whitman saw another there on August 4, 1934. Joy's earliest migration date for Kent's Island is March 30, 1936, and his latest December 13, 1935.

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[29] Gurney, "*The Gannet a Bird with a History*", Witherby and Co., London, 1913. li+567 pp.

[30] Tufts and Townsend, *Auk*, 41, 150 (1924).

[31] Samuels, "*The Birds of New England and Adjacent States*", Noyes, Holmes and Co., Boston, 1870, vii+591 pp.

[32] Bent, *U. S. Nat. Mus. Bull.* No. 121, xii+343 pp. (1922).

[33] Audubon, "*Ornithological Biography*", Adam and Charles Black, Edinburgh 1834, vol. 2, xxxii+588 pp.

Joy tells of there once being nesting colonies of the Great Blue Heron during the middle of the last century on Outer and Inner Wood Islands. At that time these places were more heavily wooded with spruce than they are to-day.

18. *Casmerodius albus egretta* (Gmelin). American Egret.

"Very rare; Grand Manan" (George A. Boardman, cf. S. L. Boardman[14], p. 309). On April 5, 1936, a specimen was found dead at Hay Island by Henry Ingalls. The plumes and primaries were saved and I had opportunity to examine them during a visit to the island the following summer. Perley Lambert collected a bird (sex undetermined) at North Head on April 12, 1930. This now resides in Moses' museum. C. J. Maynard told Deane[34] (p. 63) of examining an immature specimen in the flesh that was shot at White Head Island on November 3, 1878.

19. *Egretta thula thula* (Molina). Snowy Egret.

"Very rare; Grand Manan" (George A. Boardman, cf. S. L. Boardman[14], p. 309). The above statement was presumably substantiated by at least one specimen for Knight[35] (p. 137) wrote that the form had been taken by Boardman at Grand Manan.

20. *Florida caerulea caerulea* (Linnaeus). Little Blue Heron.

Rare visitant. Moses has in his collection a specimen which, so he informed me, was taken at Grand Manan. Moses (cf. Legge[36], p. 56) saw another on April 17, 1909, and remarked that this was the fourth time the bird had been recorded at Grand Manan. Charles B. Moseley and Henry A. Gleason, Jr., saw an individual in adult plumage at Kent's Island on August 1, 1936. Brooks[37] (p. 70) saw two young birds during his stay at Grand Manan in September and October, 1930.

21. *Butorides virescens virescens* (Linnaeus). Eastern Green Heron.

Summer resident. Herrick[11] (p. 37) wrote: "Not rare; it may breed but I do not think it does." Moses possesses a female taken at Seal Cove on June 1, 1926.

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[34] Deane, *Bull. Nuttall Ornithol. Club.*, 4, 63 (1879).
[35] Knight, *Univ. Maine Bull.* No. 3, 184 pp. (1897).
[36] Legge, *Jour. Maine Ornithol. Soc.*, 11, 56 (1909).
[37] Brooks, *Canad. Field-Nat.*, 47, 70-72 (1933).

Moses believes that the Green Heron may nest at Kent's Island for he has observed it there a number of times during the probable breeding season. Members of the Bowdoin Scientific Station, however, have not seen it there during the last three seasons.

22. *Nycticorax nycticorax hoactli* (Gmelin). Black-crowned Night Heron.

Local summer resident. Whitman noted an individual flying over Three Islands at dusk on August 12, 1934. Joy took a female at Inner Wood Island on April 21, 1926. It is now in Moses' collection.

Recently Moses found the Black-crowned Night Heron breeding on Nantucket Island. We visited this area of approximately one hundred acres on July 17, 1935, and found eleven nests. Five of of them were located near the tops of the thick conifers in one section of the island, while the other six were similarly located not far away. The young had left the nests and could be seen perching tenaciously among the uppermost branches.

23. *Nyctanassa violacea violacea* (Linnaeus). Yellow-crowned Night Heron.

The only Yellow-crowned Night Heron known to appear in the archipelago was collected by Moses at North Head on April 2, 1931. It was a female and is now preserved as an unmounted skin in Moses' museum.

24. *Botaurus lentiginosus* (Montagu). American Bittern.

Fairly common summer resident; breeds.

During my visits to the Castalia marshes I usually flushed one bird from different sections. I found no evidence of the species breeding there until July 10, 1935, when I was surprised to find myself suddenly standing within a few feet of two birds that at first appeared to be full grown. I was not a little astonished, therefore, to find that I could walk up to within arm's reach of them without flushing them. As I reached out to pick one up, it thrust its beak at me angrily, then awkwardly flew away a few feet. Eventually I caught the bird and discovered a bit of down still clinging to the freshly grown feathers,—evidence of its immaturity.

25. *Ixobrychus exilis* (Gmelin). Least Bittern.

William E. Joy took a specimen at Seal Cove in June, 1933. The specimen was later identified by Moses but it was so severely shot up that no attempt was made to preserve it. This was the only known instance of this bird's occurrence in the archipelago.

26. *Branta canadensis canadensis* (Linnaeus). Common Canada Goose.

Common transient. Near Kent's Island Joy recorded six on March 15, 1936 and 75 five days later.

Herrick[11] (p. 38) and Andros[38] (p. 151) indicated that Grand Manan was once a breeding ground of the Canada Goose.

27. *Branta bernicla hrota* (Müller). American Brant.

Common transient. At Kent's Island in the spring of 1935, A. O. Gross (cf. Lewis[39], p. 74) counted 250 in Three Island Harbour on May 24-26. Here a year later Joy counted 50 on March 16 and saw one as late as June 3. The greatest number estimated on any one day was 250 on March 30. In the spring of 1937 Joy saw the first bird on March 18 and on April 11 estimated 3,000 present. The last spring bird was seen again on June 3. Joy's latest fall date for Kent's Island is November 8, 1935.

Anser albifrons (Scopoli). White-fronted Goose.

Hypothetical. George A. Boardman (cf. S. L. Boardman[14], p. 312) listed this bird with Grand Manan as the stated locality. Knight[35] (p. 137) said that Boardman gave it as "accidental" at Grand Manan. No records admittedly based on specimens are available, so far as I know.

28. *Chen hyperborea* (Pallas). Snow Goose.

One male was taken by Moses at Grand Harbour on October 6, 1912. The bird is noticeably small, the wing measuring only 16.75 in. It is undoubtedly referable to the smaller race, *C. h. hyperborea*, as Brooks[37] (p. 71) has previously indicated. George A. Boardman (cf. S. L. Boardman[14], p. 312) has listed both the lesser and greater forms as occurring at Grand Manan, the former being estimated as "Accidental", the latter as "Rare".

29. *Anas platyrhynchos* Linnaeus. Mallard.

Herrick[11] (p. 38) considered this bird very rare. It is held as a rare transient to-day by Moses and Joy who have shot several birds.

30. *Anas rubripes* (Brewster). Black Duck.

Fairly common to common resident; nests.

At Kent's Island on April 11, 1937, Joy found a nest with eleven eggs. The year before he found a nest with seven eggs on May 11.

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[38] Andros, *Ornithol. and Ool.*, 12, 151-152 (1887).
[39] Lewis, *Auk*, 54, 73-95 (1937).

Henry R. McLaughlin informed me that he had seen seven broods of Black Ducks at one time on Long Pond during June, 1935. While working over the Castalia Marshes on June 6, 1935, I surprised an adult which, instead of flying away, flopped along on the ground in front of me, obviously feigning injury. In a few moments it flew into the air and circled me again and again, quacking almost constantly. Try as I would, I could not locate any nest or young. During a later visit to this same place on June 22, 1935, I found the bird and witnessed a similar performance but this time I found two young partially feathered and still with a large amount of down on their backs. They were unable to fly.

The legs and feet of the adult which I watched feigning injury were noticeably dark, there being little, if any, indication of redness. I feel safe in assuming that this bird was *A. r. tristis* and not the questionably valid race, *A. r. rubripes*.

Chaulelasmus streperus (Linnaeus). Gadwall.

Hypothetical. "Rare" (Herrick[11], p. 38). Herrick's inclusion of the Gadwall in his list with the above statement of its status is apparently not based on specific records.

31. Mareca penelope (Linnaeus). European Widgeon.

Preserved in Moses' collection is a female specimen taken at Nantucket Island on November 1, 1927.

32. Mareca americana (Gmelin). Baldpate.

Rare transient; a few, according to Moses and Joy, being observed during the fall of the year. A female, shot by Joy at North Head on December 5, 1901, resides in Moses' museum.

33. Dafila acuta tzitzihoa (Vieillot). American Pintail.

Rare to fairly common transient. Moses and Joy have found Pintails more common in the fall, coming early in September. Moses has a female taken on one of the Duck Islands on March 2, 1918. Joy saw ten at Kent's Island on March 13, 1936, and six the previous fall on October 20.

34. Nettion carolinense (Gmelin). Green-winged Teal.

Rare as spring transient but fairly common fall transient. A male was taken by Moses at White Head Island on March 1, 1916, and is now mounted in his museum.

35. Querquedula discors (Linnaeus). Blue-winged Teal.

Rare as a spring transient and summer resident; fairly common to rare fall transient; breeds. Moses has a male taken at Sheep Island on April 15, 1919. Joy saw twenty on a pond on that island on September 20, 1935.

Dr. Anne E. Perkins saw a female with seven newly hatched young on Whale Cove Pond on July 15, 1935. The following day I visited the area and flushed the female from the shore. The bird circled me a number of times, protesting my presence vociferously. The young I failed to see since they were apparently hidden in the thick grass bordering the pond. During this same breeding season Moses knew of a pair nesting at Long Pond.

36. *Spatula clypeata* (Linnaeus). Shoveller.

On January 5, 1935, Moses collected a male Shoveller on Nantucket Island. This specimen was deposited in the National Museum of Canada[40].

37. *Aix sponsa* (Linnaeus). Wood Duck.

Moses informs me that he has known only two Wood Ducks to be recorded in the archipelago. Both of these birds were collected, one coming from Ohio Pond and the other from Three Islands. These specimens he mounted and later sold.

38. *Nyroca americana* (Eyton). Redhead.

Apparently a rare transient and winter resident. Moses has two specimens in his collection. One, a male, was taken at Nantucket Island on October 20, 1927; the other, a female, was taken near Grand Manan on January 4, 1906.

Nyroca valisineria (Wilson). Canvas-back.

Hypothetical. "Rare" (Herrick[11], p. 38). Herrick's reasons for listing the Canvas-back are unknown to me. No references to specific records have come to my attention.

39. *Nyroca marila* (Linnaeus). Greater Scaup Duck.

A common spring and fall transient; occasional winter resident. Moses has one specimen in his collection which I believe, on cursory examination, to be referable to this species. This is a female taken at Nantucket Island on February 10, 1917. Its wing measures 8.75 in.

40. *Nyroca affinis* (Eyton). Lesser Scaup Duck.

In all probability this species occurs as a rare spring and fall transient. Joy knows of one being shot between Hay and Sheep Islands. Moses has a male specimen taken at North Head on April 1, 1904. Its wing measures 7.87 in.

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[40] Taverner, *Canad. Field-Nat.*, 50, 142 (1936).

41. Glaucionetta clangula americana (Bonaparte). American Golden-eye.

Moses[19] (p. 14) saw two on December 26, 1908. He has in his collection a male taken at Grand Manan on December 18, 1922, and a female taken at Nantucket Island on January 3, 1912.

42. Glaucionetta islandica (Gmelin). Barrow's Golden-eye.

Very rare transient; probably rare winter resident. Moses has a male specimen shot at Little Duck Island on November 25, 1921.

43. Charitonetta albeola (Linnaeus). Buffle-head.

Transient and winter resident. "Very common in winter" (Herrick[11], p. 38). Moses and Joy now consider the Buffle-head as rare at all times at Grand Manan. A female taken at North Head on November 20, 1909, and a male taken at Nantucket Island on October 16, 1925, are in Moses' collection.

44. Clangula hyemalis (Linnaeus). Old-squaw.

Common transient and winter resident. Moses[19] (p. 14) saw many of these birds on December 26, 1908. He has two specimens collected on January 18, 1908—a female from Long Island and a male from Grand Manan. Joy estimated 550 in the vicinity of Kent's Island on February 10, 1936; 400 on March 24, 1936; and 100 on March 31, 1936. In the files of the Bureau of Biological Survey, Washington, D.C., are a series of migration records of this species kept by Simeon F. Cheney from 1888 to 1891. His latest spring record is May 10, 1889. He noted them as early in the fall as October 16, 1887.

Herrick[11] (p. 38) saw a pair in "full breeding plumage" that had been shot on June 18 and concluded that the species might be breeding in the vicinity. Sweet and Floyd (Whitman, MS) observed an immature male in the vicinity of the Basin at Kent's Island during most of August, 1933. It is very unlikely that the Old-squaw has ever bred in the archipelago.

45. Histrionicus histrionicus histrionicus (Linnaeus). Eastern Harlequin Duck.

Very rare winter resident. "Common in winter" (Herrick[11], p. 38). Moses has a male and a female taken at Grand Manan on February 3, 1908.

Audubon[1] (p. 612) reported the Harlequin Duck as breeding on "the Seal, White Head and Grand Manan Islands". He wrote (p. 163): "On the 31st of May, 1833, I found them breeding on White Head Island, and other much smaller places of a similar nature, in the same part of the Bay of Fundy. There they place their nests under the bushes or amid the grass, at the distance of twenty or thirty yards from the water." Brewer[2] (pp. 298-299) considered Audubon in error, stating that he probably confused the species with breeding Red-breasted Merganser. One is decidedly inclined to accept Brewer's criticism as logical, believing it very improbable that this form ever bred as far south as Grand Manan, at least in the great numbers indicated.

46. *Camptorhynchus labradorius* (Gmelin). Labrador Duck.

The last specimen of this now extinct species to be taken at Grand Manan is accounted for by George A. Boardman (cf. Dutcher[41], p. 214). He wrote: "The last one I know to have been taken was shot by S. F. Cheney, at Grand Manan, in April, 1871. It was given to Harold Herrick, who subsequently gave me the skin. I sent it to John Wallace of New York to be mounted for Prof. S. F. Baird of the Smithsonian Institution. Not knowing its value, Wallace let some one get the skin from him and it was lost to the Smithsonian, as he could not tell who had it."

47. *Somateria mollissima borealis* (Brehm). Northern Eider.

Apparently an uncommon to fairly common winter resident. Moses took one bird near Three Islands during the middle of December, 1925.

48. *Somateria mollissima dresseri* Sharpe. American Eider.

Common summer resident. In 1936 Joy noticed the first bird to arrive at Kent's Island on April 7.

In 1936 approximately 150 pairs were believed to have bred on Three Islands, 15 pairs on Outer Wood Island, and 20 pairs on the White Horse. Joy found a nest at Kent's Island as early as May 9, 1936, and counted 160 males in the surrounding water the following day. On May 24, 1935, A. O. Gross found a number of nests at Kent's Island. One contained five eggs, three contained four eggs, and five contained three eggs. Joy saw downy young eiders there on June 3, 1936 and Whitman reported a nest with newly hatched young as late as August 12, 1934. On July 20, 1935, I saw two females, one with three and one with four downy young, swimming about in the vicinity of two of the outermost Murr Ledges, at least three and a half miles from Kent's Island, the nearest possible breeding ground.

Apparently the American Eider was once a very common, if not abundant, breeding bird in the Grand Manan archipelago. Audubon[1] (p. 343) reported that on May 31, 1833, his son's party killed six eiders on Grand Manan "where the birds were seen in considerable numbers, and were just beginning to breed". Herrick[11] (p. 38) noted it "breeding in abundance on all the small islands about Menan" but stated that it was fast decreasing in numbers due to the depredations of man. Pearsall[12] (p. 524) and Andros[38] (p. 151) likewise spoke of the decrease in numbers. During July and August, 1923, Townsend[42] (p. 142) believed it "nearly gone". He saw only three or four individuals near the White Horse and "Green Islands".

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[41] Dutcher, *Auk*, 8, 201-216 (1891).

49. *Somateria spectabilis* (Linnaeus). King Eider.

Very rare transient and winter resident. In Moses' collection there is one female taken at Nantucket Island on November 17, 1908.

50. *Melanitta deglandi* (Bonaparte). White-winged Scoter.

Common transient and winter resident. Moses has a male specimen taken on one of the Duck Islands on November 1, 1908. He[19] (p. 14) saw four on December 26, 1908, at Grand Manan. Bent and Durfee saw five near Hay Island on June 15, 1891, probably late transients.

Audubon[1] (p. 356) said that this scoter bred at Grand Manan. No doubt this was an error or lapse of memory.

51. *Melanitta perspicillata* (Linnaeus). Surf Scoter.

Fairly common transient and winter resident. A male taken at Duck Island on December 11, 1908, is in Moses' possession. On December 26, 1908, Moses[19] (p. 14) saw one individual. Herrick[11] (p. 38) told of a specimen which alighted in a yard on White Head Island one June day and was captured alive. This bird was probably crippled.

52. *Oidemia americana* Swainson. American Scoter.

Transient and winter resident. "Common in winter" (Herrick[11], p. 38). Moses and Joy believe this bird to be the least common of the three scoters.

53. *Erismatura jamaicensis rubida* (Wilson). Ruddy Duck.

"Uncommon" (Herrick[11], p. 39); probably occurs only as a straggler to-day. Joy has observed an individual twice on the smaller ponds of Grand Manan and once in the salt water directly off shore.

54. *Lophodytes cucullatus* (Linnaeus). Hooded Merganser.

Apparently a very rare transient and winter visitor. "Not common and does not breed (Herrick[11], p. 39). During one fall Moses saw two individuals at Grand Manan. Carol Wilcox shot one male in full breeding plumage in the fall of 1934.

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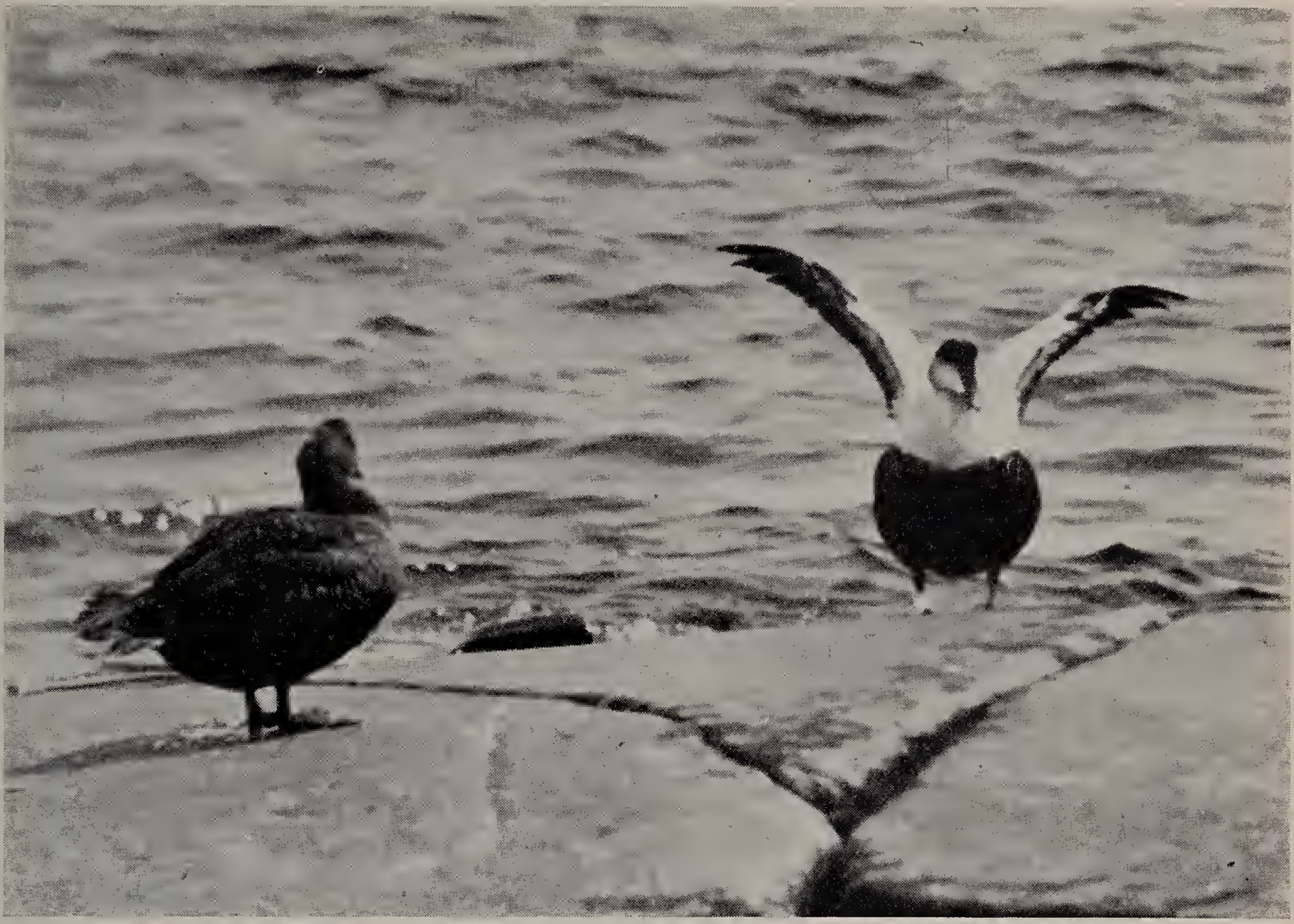
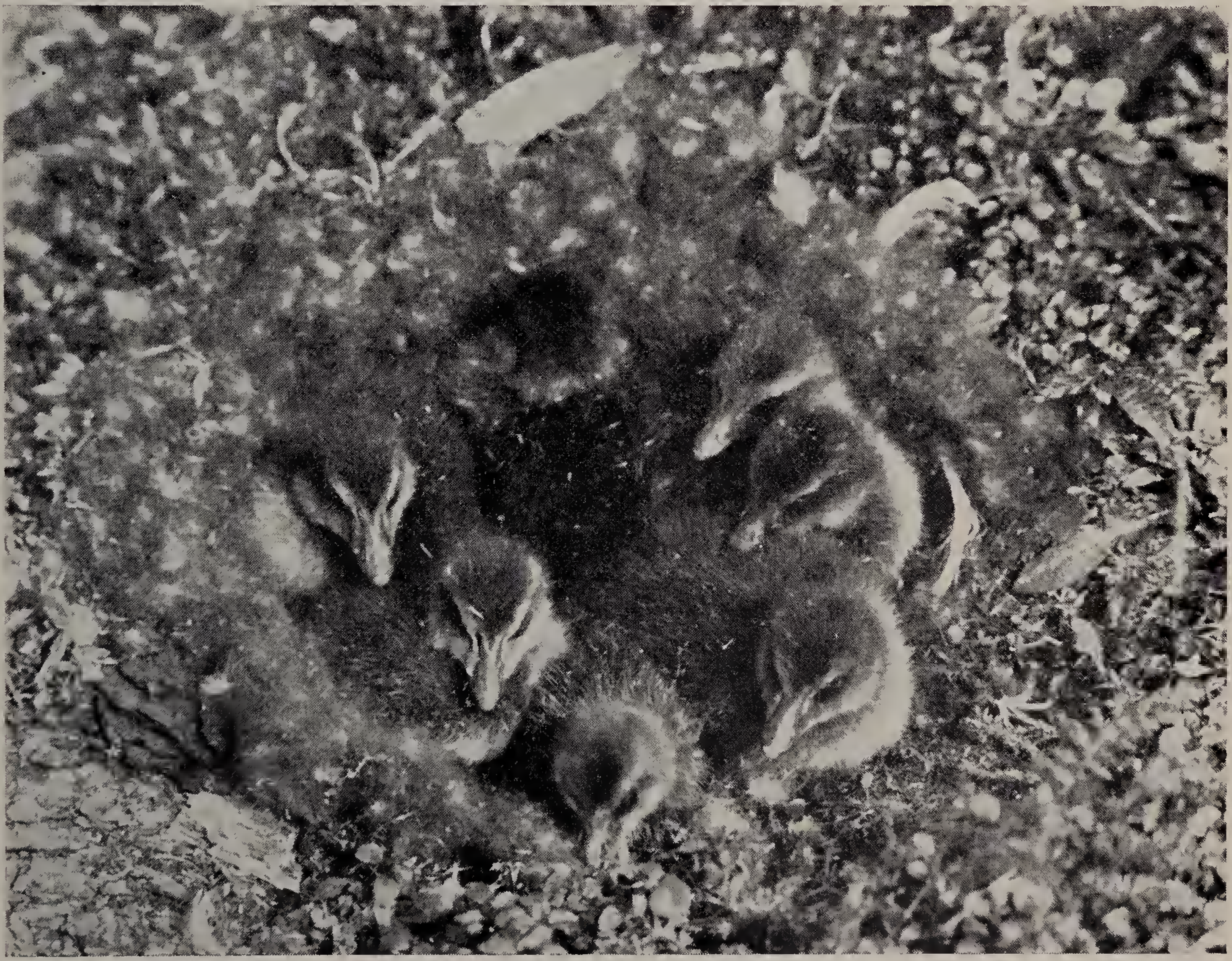
[42] Townsend, *Canad. Field-Nat.*, 37, 141-144 (1923).



A female and male American Eider on the shore of Kent's Island. The male bird is just leaving the water.



A newly hatched brood of seven American Eiders at Kent's Island.

Photographs by Alfred O. Gross.

55. *Mergus merganser americanus* Cassin. American Merganser.

Rare transient. "Common" (Herrick[11], p. 39). Moses has one male taken at Eel Lake on April 5, 1909.

56. *Mergus serrator* Linnaeus. Red-breasted Merganser.

Common transient and winter resident; probably a summer resident at one time. Two birds, one definitely determined to be a male, were taken at Long Island on January 18, 1908, and reside in Moses' collection. Moses[19] (p. 14) saw fifty on December 26, 1908, nearly all of which were males. I observed one male off the shore of Machias Seal Island on June 3, 1935.

Herrick[11] (p. 39) stated: "It used to breed but has almost entirely left the island during the season of incubation, those remaining being only immature or unproductive birds." In recent years very few birds have been observed in the archipelago during the breeding season and it is very unlikely that it breeds there now.

57. *Cathartes aura septentrionalis* Wied. Turkey Vulture.

Joy shot a Turkey Vulture on Inner Wood Island during the early fall of 1900. His uncle, Mariner Wilcox, shot another "some years before".

58. *Coragyps atratus atratus* (Meyer). Black Vulture.

George A. Boardman (cf. S. L. Boardman[14], p. 178) wrote of a Black Vulture having been taken at Grand Manan in the year 1869. This was a bird new to his list. Townsend[43] (p. 130) was certain of the identification of a Black Vulture near North Head on August 9, 1924.

59. *Astur atricapillus atricapillus* (Wilson). Eastern Goshawk.

Rare transient and winter resident. Moses has a male taken at North Head on November 14, 1927.

While the Goshawk should nest in the extensive coniferous forests in the interior of Grand Manan, I know of no records of its breeding or of its occurrence here during the summer.

60. *Accipiter velox velox* (Wilson). Sharp-shinned Hawk.

Common transient and fairly common summer resident; casual in winter. Moses has one male taken at Grand Manan on April 8, 1908. He (cf. Legge[36], p. 56) saw a large flight of this form on April 6, 1909. I saw one individual flying along the Dark Harbour road on June 8, 1935, and saw another at Deep Cove on June 11,

[43] Townsend, *Auk*, 42, 130 (1925).

1935, being angrily pursued by a Robin. Allen observed the bird twice at Grand Manan. Norton observed a Sharp-shinned Hawk being assailed by the terns feeding in the vicinity of the Yellow Murr Ledge on August 26, 1936. A day later he saw another being driven by the terns as it attempted to fly over Machias Seal Island. Whitman recorded an individual flying low over Kent's Island on August 29, 1934. Joy noted one at Kent's Island on November 7, 1935, and collected one there on February 8, 1936.

Herrick[11] (p. 36) once secured a nest containing four eggs from White Head Island.

61. Accipiter cooperi (Bonaparte). Cooper's Hawk.

Allen observed a pair at Dark Harbour on August 22, 1929. This species is undoubtedly of more frequent occurrence than observations show.

62. Buteo borealis borealis (Gmelin). Eastern Red-tailed Hawk.

Rare to uncommon transient; casual in summer; not known to breed. Favour (Whitman, MS) observed one at Three Islands on August 14, 1934. Joy recorded two at Kent's Island on October 1, 1935. Moses has two birds collected at North Head,—a female taken on October 1, 1910, and a male taken on October 10, 1915.

63. Buteo lineatus (Gmelin). Red-shouldered Hawk.

"Not rare" (Herrick[11], p. 36). Casual in summer; not known to breed. Saunders observed one at Grand Manan on August 21, 1926. Although there is a paucity of records for this species during the spring and fall, it seems likely that the Red-shouldered Hawk must now be at least *uncommon* during migration.

Birds occurring in the archipelago are presumably referable to the northern race, *B. l. lineatus*.

64. Buteo platypterus platypterus (Vieillot). Broad-winged Hawk.

Apparently a rare transient and summer resident. Townsend[42] (p. 143) saw one bird on August 16, 1923, and another on August 17, 1923, both at North Head. Saunders identified one at Grand Manan on September 2, 1928.

On June 18, 1935, Sirdar Ingalls showed me a nest of the species containing three eggs. The nest was located about a mile up the Seal Cove Stream in the crotch of a large white birch nearly twenty feet from the ground. The nesting bird was collected and proved to be a female.

65. *Buteo lagopus s.johannis* (Gmelin). American Rough-legged Hawk.

Fairly common transient and rare winter resident. Moses has one specimen, a female, taken at Grand Manan on February 24, 1926.

Herrick[11] (p. 36) stated that this bird "may breed" but it is highly improbable.

66. *Aquila chrysaëtos canadensis* (Linnaeus). Golden Eagle.

Rare transient and visitant. Audubon[33] (p. 485) wrote of a Golden Eagle "soaring aloft" as he approached Grand Manan. Moses has in his collection a female taken at Grand Manan on October 1, 1905, and a male taken at White Head on October 1, 1915.

67. *Haliaeetus leucocephalus* (Linnaeus). Bald Eagle.

Resident and transient. On June 5, 1935, I saw an immature bird resting on a stump in the Castalia Marshes and on the following day I noticed another flying low over the Dark Harbour road. During a visit to Dark Harbour on June 8, 1935, I observed an adult circling far up in the sky. A native of the vicinity, who was working along the shore, saw me watching the bird and remarked that he had seen the bird almost every day during the spring. I have no doubt but that the bird had a nest in the big timber back from the cliffs. Joy recorded Bald Eagles regularly at Kent's Island from December 18, 1935, to March 8, 1936.

Herrick[11] (p. 36) listed the species as a very common resident. On February 20 (year not mentioned), he said, Cheney found a nest with one egg in a tall pine "up the main island". The embryo was "well advanced, but frozen". The parent birds were seen "sailing overhead at a respectful distance". Pearsall[12] (p. 524) procured a set of eggs which were taken in April.

The summer resident Bald Eagles probably belong to the southern race, *H. l. leucocephalus*. Many of the winter birds, however, are very likely to be of the northern race, *H. l. alascanus*. A male specimen in Moses' museum which was taken at Fish Head on February 12, 1923, bears out this belief. It is obviously large with a wing measuring 23.60 in.

68. *Circus hudsonius* (Linnaeus). Marsh Hawk.

Common transient and summer resident. Moses has a male taken at Grand Manan on March 10, 1926. At Kent's Island Joy recorded the first Marsh Hawk for 1936 on April 1 and for 1937 on April 13. I observed it frequently during my stay at Grand Manan and found it to be unquestionably the most common hawk.

The Marsh Hawk breeds commonly on many of the isolated heaths. Carol Wilcox showed me an old 1934 nest of the species on a large heath about a mile and a half to the west of Seal Cove. Vinton Green reported a nest containing five well-feathered young found near Ingall's Head on June 20, 1935.

69. *Pandion haliaëtus carolinensis* (Gmelin). Osprey.

Fairly common transient and summer resident. I saw one bird at Castalia on June 12, 1935; another at Red Head Point on June 13, 1935; and still another at Deep Cove on June 14, 1935.

On June 19, 1935, Samuel E. Harvey and I found a nest of the Osprey near the edge of Miller's Pond. The nest was situated on the top of a thirty-foot stump entirely devoid of branches. Although it was impossible to examine the contents, from the behavior of the parent birds, we judged that young were present.

70. *Falco rusticolus* Linnaeus. Gyrfalcon.

Rare winter visitant. Moses has three specimens taken at North Head on the following dates: November 10, 1911; November 1, 1900; February 10, 1927. During November, 1935, Joy noted seven Gyrfalcons at Kent's Island. Four were in gray plumage and three were in white. Two of the white birds were shot but not saved.

The specimens in Moses' collection have not been critically examined, consequently their subspecific status remains undetermined.

71. *Falco peregrinus anatum* Bonaparte. Duck Hawk.

Fairly common transient. In Moses' collection there is a male taken at North Head on March 2, 1910, and a female taken in the same vicinity on September 22, 1908. Allen saw a pair above the cliffs on the northeastern side of Grand Manan. Saunders saw "several" during his visit.

The Duck Hawk used to breed on Grand Manan, probably in considerable numbers, for the high cliffs along the northern and entire western shore are particularly suited to their needs. Yet, oddly enough, there is only one reported breeding locality. This was first described by Herrick[11] (p. 35) thus: "There is a place between 'Fish Head' and the 'Old Bishop' known as the 'Seven Days' Work', where the cliff is divided into seven strata as sharply defined as lines of masonry. On an indentation in the face of this cliff, about one hundred feet from the top, and one hundred and fifty feet from the bottom, a pair of these falcons have had their eyry for a succession of years; secure alike from the assaults of the most zealous naturalist and the small boy of bird's-egging proclivities." The Duck Hawk continued to nest regularly on these cliffs for years thereafter. When Brownson[44] (pp. 75-76) visited the vicinity of

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[44] Brownson, *Jour. Maine Ornithol. Soc.*, 10, 72-77 (1908).

Seven Days' Work with Moses on August 4, 1908, he saw three birds and assumed that they were a nesting female and her two young. As Smith[21] (pp. 54-55) has intimated, however, it was not long after Brownson's visit that the Duck Hawk was intentionally extirpated. It has not since attempted to nest there.

72. *Falco columbarius columbarius* Linnaeus. Eastern Pigeon Hawk.

Irregularly common transient. Moses has in his collection a bird taken at Three Islands on April 15, 1931. About May 15, 1935, Samuel E. Harvey saw a large flight of this species at Machias Seal Island and shot four, the decomposed bodies of which I examined on June 3, 1935. Whitman reports one seen at Kent's Island on July 30, 1934. Saunders saw four during his visit to Grand Manan.

73. *Falco sparverius sparverius* Linnaeus. Eastern Sparrow Hawk.

Common transient and rare summer resident. Joy saw two at Kent's Island on April 1, 1936. Moses (cf. Legge[36], p. 56) reported them "abundant" at Grand Manan on April 6, 1909. He has one in his collection taken at Grand Manan two days later. Sweet (Whitman, MS) saw one at Kent's Island during July, 1933. Whitman reported another there on August 4, 1934.

Moses tells me that the Sparrow Hawk was once a common nesting species on Grand Manan, but that he has not observed it during the breeding season in recent years. On July 15, 1935, I located a pair of nesting birds about two miles up the Grand Harbour Brook. The hole in which the nest was placed was in a tall dead tree in a large open area and could not be climbed. These were the only birds I observed in the archipelago.

74. *Bonasa umbellus* (Linnaeus). Ruffed Grouse.

Common resident. I observed grouse on a number of occasions in 1935, finding it widely distributed in the interior of the island.

On July 8, 1935, Lincoln Harvey and Ronald Russell flushed a brood of grouse at Deep Cove. The chicks were newly hatched. Sirdar Ingalls found a nest containing nine eggs on June 18, 1935. The eggs hatched on July 27. I flushed one brood at Watt Pond on June 28, 1935, and came upon two more in the woods between Dark Harbour and Little Dark Harbour on July 1, 1935. The young in all cases were well able to fly.

As these birds observed were not collected, it cannot be stated whether they were *B. u. togata*, the so-called Canada Ruffed Grouse, or *B. u. thayeri*, the more easterly race.

75. *Rallus limicola limicola* Vieillot. Virginia Rail.

Rare transient and very rare summer resident.

On June 3, 1908, Moses found a nest of this rail in Whale Cove Marsh. The eggs together with the incubating bird were taken and are now in his collection.

76. *Porzana carolina* (Linnaeus). Sora.

Fairly common transient; possibly a summer resident and breeding bird. Moses (cf. Legge[36], p. 56) heard one at Grand Manan on April 21, 1909. He has in his collection three birds taken at North Head on the following dates: September 2, 1908 (male); September 10, 1908 (female); December 11, 1908 (female).

Bent[45] (p. 313) has listed Grand Manan as being a breeding ground of the Sora, although the reason for so doing is not known to me. Joy believes that the Sora once nested in the marsh grass surrounding the fresh water pond on Hay Island.

77. *Coturnicops noveboracensis* (Gmelin). Yellow Rail.

Apparently very rare transient. In 1880 George A. Boardman (cf. S. L. Boardman[14], pp. 183-184) wrote that he heard of one being killed "at the Grand Manan lighthouse". Brooks[37] (p. 70) attempted to collect a bird at Whale Cove Marsh on October 7, 1930, but the specimen was "winged and lost".

78. *Ionornis martinica* (Linnaeus). Purple Gallinule.

Under the date of December 18, 1869, George A. Boardman (cf. S. L. Boardman[14], p. 178) wrote of adding three new birds to his list for the year, of which one was a Purple Gallinule taken at Grand Manan. Moses' father, John R. Moses, found a specimen near the Swallow Tail lighthouse "about 1885". It was mounted and remained in his collection for a number of years but was eventually destroyed.

79. *Gallinula chloropus cachinnans* Bangs. Florida Gallinule.

Another bird which George A. Boardman (ibid.) added to his list for 1869 was a Florida Gallinule, likewise taken at Grand Manan. Brooks[37] (p. 70) collected a young Florida Gallinule at Whale Cove Marsh on October 10, 1930.

80. *Fulica americana americana* Gmelin. American Coot.

Rare fall transient. Moses has a female taken at Long Pond on November 5, 1921.

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[45] Bent, *U. S. Nat. Mus. Bull.* No. 135, xii+490 pp. (1926).

81. *Haematopus palliatus palliatus* Temminck. American Oyster-catcher.

George A. Boardman once told Brewer (cf. Baird, Brewer and Ridgway[5], p. 113) that a single specimen had been taken at Grand Manan.

Upon the authority of Audubon[1] (p. 182), the Oyster-catcher once bred in the Bay of Fundy. It may, therefore, have been a summer resident of the archipelago.

82. *Vanellus vanellus* (Linnaeus). Lapwing.

In December, 1927, Joy secured three specimens, one at Three Islands and two at Outer Wood Island. Moses has a female taken at Hay Island on January 6, 1928.

83. *Charadrius melodus* Ord. Piping Plover.

Fairly common transient. Moses has a specimen taken on Nantucket Island on May 1, 1919. Saunders observed the species twice.

The statement by Boardman[13] (p. 128) that the Piping Plover breeds "on islands the middle of June" infers that the species once nested in the archipelago. Nevertheless, Moses and Joy have never found evidence of its breeding.

84. *Charadrius semipalmatus* Bonaparte. Semipalmated Plover.

Abundant transient; frequently observed during all the summer months. Whitman saw the species at Three Islands on June 25, 1934. A. O. Gross noted flocks of from thirty to fifty at Kent's Island on July 1, 1932, and by July 5 he found them very common.

The Semipalmated Plover has bred in the archipelago in the past. In the United States National Museum there is a set of eggs (no. 21285) taken on Nantucket Island by E. Cheney on June 21, 1875. Pearsall[12] (p. 524) stated that a single pair bred for several successive years on Nantucket Island. In 1878 he found a young bird there "just hatched".

85. *Oxyechus vociferus vociferus* (Linnaeus). Killdeer.

Generally a rare transient. Moses has a female taken at Nantucket Island on March 19, 1918. George A. Boardman (cf. Chadbourne[46], p. 259) noted "quite a flight" at Grand Manan from December 1-15, 1888.

86. *Pluvialis dominica dominica* (Müller). American Golden Plover.

Fairly common transient, particularly in the fall. Moses has a specimen, a female, taken on Nantucket Island on November 10, 1926.

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[46] Chadbourne, *Auk*, 6, 255-263 (1889).

87. *Squatarola squatarola* (Linnaeus). Black-bellied Plover.

Common transient. Moses has three males, one taken at Nantucket Island on May 5, 1912, another at Ross Island on August 1, 1909, and another at the Castalia Marshes on August 7, 1908. Whitman observed this species at Kent's Island for the first time in 1934 on August 2. From then on until August 20 the flocks of this species increased in size. When he left the island at the end of August, he reported "hundreds".

88. *Arenaria interpres morinella* (Linnaeus). Ruddy Turnstone.

Very common transient. I saw two birds at Machias Seal Island on July 19, 1937, and observed the species every day from then on during my stay. Hyde observed three at Kent's Island on July 24 1936. Moses has a male taken at Woodward's Cove on August 24, 1908.

89. *Philohela minor* (Gmelin). American Woodcock.

Common transient and summer resident. I heard three males at one time going through their flight performances on the evening of May 31, 1935, at Deep Cove. On June 4, 1935, a specimen was given me that had apparently been killed by flying into a telephone wire. On June 11, 1935, I flushed four birds at different intervals during a walk through the woods to the west of Deep Cove. Allen observed one bird on August 14, 1929, and five on August 16, 1929, along the "lower road" from Whale Cove to North Head. Whitman flushed a bird at Kent's Island on August 12 and 19, 1934. Saunders saw one on August 23, 1926.

The Woodcock undoubtedly breeds commonly on Grand Manan although I personally found no nests or young. Joy, however, found a nest with four eggs near Seal Cove on April 10, 1935. Pearsall[12] (p. 524) found a family, the "young just able to fly", on June 10 (year not stated).

90. *Capella delicata* (Ord). Wilson's Snipe.

Rare transient. Moses has three specimens taken at Grand Manan on the following dates: April 21, 1908; April 22, 1908 (male); October 21, 1908 (female). At Kent's Island Joy recorded the Wilson's Snipe as early as April 1, 1936, and as late as October 16, 1935.

Numenius americanus Bechstein. Long-billed Curlew.

Hypothetical. "Not rare in autumn" (Herrick[11], p. 37). Since the Long-billed Curlew, as Forbush[25] (p. 545) believes, may have been "an irregularly common to uncommon or rare migrant" along the New England coast and may have ranged north to Newfoundland and Labrador, Herrick's inclusion of this bird may have been thoroughly justified. Nevertheless, no birds are known to have been taken or definitely recorded in the archipelago.

91. Phaeopus hudsonicus (Latham). Hudsonian Curlew.

Fairly common transient. Moses has a specimen taken at Bancroft's Marsh on August 10, 1909. Whitman recorded this species at Kent's Island on July 24, 1934. From then on until the middle of August he remarked that as many as eight were seen at a time.

Phaeopus borealis (Forster). Eskimo Curlew.

"Rare" (Herrick[11], p. 37). Undoubtedly this now virtually extinct form was once a common, if not abundant, transient in the Grand Manan archipelago. Yet there are no specimens and records reported from this region.

92. Bartramia longicauda (Bechstein). Upland Plover.

Rare transient and summer visitant. Moses has a male that he collected at Kent's Island on August 29, 1932. Joy saw one at Kent's Island as late as October 1, 1935.

93. Actitis macularia (Linnaeus). Spotted Sandpiper.

Common summer resident on nearly all the large islands of the archipelago.

Mayr estimated seven pairs residing at Kent's Island in 1933 and Whitman estimated the same number the following year. In 1932 I found four pairs nesting on Machias Seal Island; in 1935 Cruickshank found six pairs; in 1937 I banded the downy young of five broods and estimated eight pairs nesting there altogether. The earliest nesting date for the archipelago is that of a nest with three eggs found by Mrs. Edgar R. Russell at Machias Seal Island on June 3, 1935. A fourth egg appeared in the nest on the following day. Other breeding records for the archipelago are as follows: A nest with one egg at Kent's Island, June 9, 1935 (Joy); a nest with four eggs at Seal Cove, June 13, 1935 (Pettingill); a nest with four eggs on the White Horse, June 15, 1891 (Durfee); a nest with eggs hatching at Kent's Island, June 23, 1932 (A. O. Gross); a nest with eggs at Machias Seal Island, July 19, 1935 (Cruickshank).

94. Tringa solitaria Wilson. Solitary Sandpiper.

Rare transient and summer visitant; common according to Herrick[11] (p. 37). Favour (Whitman, MS) observed one at Kent's Island on August 9, 1934. Saunders saw two on August 31, 1936.

Birds occurring here are probably of the typical eastern race, *T. s. solitaria*, undergoing migrations to and from their more northerly breeding grounds.

95. Catoptrophorus semipalmatus semipalmatus (Gmelin). Eastern Willet.

Rare summer visitant. Moses has a male specimen taken at Grand Manan on August 25, 1921. Whitman recorded one at Kent's Island on August 20, 1934.

96. Totanus melanoleucus (Gmelin). Greater Yellow-legs.

Very common transient. A male specimen taken at Grand Manan on May 18, 1908, is in Moses' collection. I noted one on the Castalia Marshes on June 15, 1935. Whitman saw one at Three Islands on July 21, 1934. Moses has a female taken on Bancroft's Marsh on August 29, 1909.

97. Totanus flavipes (Gmelin). Lesser Yellow-legs.

Probably rare spring transient but fairly common fall transient. Cruickshank observed the species at Machias Seal Island on July 19, 1934, and Whitman observed three birds at Hay Island on July 24 of that same year. Whitman saw individual groups quite frequently during the first part of August, 1934. Moses has a female taken at Kent's Island on August 5, 1895.

98. Calidris canutus rufus (Wilson). American Knot.

Generally rare transient but at times fairly common during the late summer and fall migration. At Machias Seal Island on July 20, 1937, I saw one flock containing fifteen birds. Smaller flocks were seen about the island during the remainder of my stay. On July 27 I secured one female at nearby Gull Rock. Whitman reported a small flock seen off Sheep Island on August 22, 1934. Saunders saw the Knot on August 25, 1926.

99. Arquatella maritima (Brünnich). Purple Sandpiper.

Very common transient and winter resident. Moses has two male specimens that were taken at "Little Wood Island" [=Outer Wood Island] on May 30, 1925. Herrick[11] (p. 37) took a single specimen on August 13, 1872. Norton saw seven birds at the Yellow Murr Ledge on August 26, 1936. Moses[19] (p. 14) saw a flock of about forty at Long Island on December 19, 1908.

100. Pisobia melanotos (Vieillot). Pectoral Sandpiper.

Rare spring and common late summer and fall transient. Cruickshank saw one at Machias Seal Island on July 20, 1935. Moses has a female taken at Castalia on August 14, 1908. Allen saw two at the Yellow Murr Ledge on August 23, 1929.

101. Pisobia fuscicollis (Vieillot). White-rumped Sandpiper.

Rare spring transient; common during the late summer and fall migration. Moses has a female taken at Kent's Island on August 5, 1925, and a male and female taken at Woodward's Cove on August 24, 1908. In 1934 Whitman found the species "most common" at Three Islands during the middle of August, being first observed August 9. He said that sometimes there were flocks as large as a hundred.

102. Pisobia minutilla (Vieillot). Least Sandpiper.

Abundant transient, seen commonly even in June and July. I saw eight at Deep Cove on June 3, 1935, and well over a hundred at Kent's Island on July 11, 1935. Whitman has noted that they are very common at Three Islands from about July 10 on into the fall.

Erolia testacea (Pallas). Curlew Sandpiper.

Hypothetical. Although this species is listed by George A. Boardman (cf. S. L. Boardman[14], p. 310) as accidental at Grand Manan no reference is made to a specimen having been taken.

103. Pelidna alpina sakhalina (Vieillot). Red-backed Sandpiper.

Rare transient except in the fall when it is sometimes fairly common. Moses has a male specimen taken at Nantucket Island on November 10, 1919.

104. Limnodromus griseus (Gmelin). Dowitcher.

Rare transient in the spring; very common transient in the late summer and fall. I observed a flock of 35 Dowitchers at Machias Seal Island on July 11, 1937, and noted many smaller flocks there during the remainder of the month. I saw six on the Yellow Murr Ledge on July 19, 1935. Pearsall[12] (p. 524) shot a female at Grand Manan on July 13, 1877. Moses has two females, one taken at Kent's Island on August 5, 1925, and the other taken at Three Islands on August 10, 1925.

105. Micropalama himantopus (Bonaparte). Stilt Sandpiper.

Very rare transient. Sweet and Floyd (Whitman, MS) saw one bird in the Basin at Kent's Island during August, 1933. In the National Museum of Canada there is a specimen in the barred plumage which was taken at North Head on August 3, 1925.

106. *Ereunetes pusillus* (Linnaeus). Semipalmated Sandpiper.

Abundant transient. During the summer of 1934 Whitman first saw the species at Three Islands on July 4; later in the summer he saw "thousands" of them. In 1937 I recorded the first Semipalmated Sandpiper at Machias Seal Island on July 7 and saw increasing numbers of them on every day thereafter. I saw a flock of well over a hundred birds at the Castalia Marshes on July 19, 1935. On the following day I saw five at the Yellow Murr Ledge.

107. *Limosa haemastica* (Linnaeus). Hudsonian Godwit.

Apparently very rare transient. Cheney sent Herrick[11] (p. 37) a pair of these birds that he shot in November, 1871. Cheney said that these were the only ones he had ever seen.

108. *Philomachus pugnax* (Linnaeus). Ruff.

Brewer (cf. Baird, Brewer and Ridgway[5], p. 294) stated that "examples [of Ruff] have been taken at Grand Menan". In the collection of the United States National Museum there is a specimen (no. 52391) of an adult bird, unsexed, labelled "Grand Manan, G. A. Boardman", with no date.

109. *Crocethia alba* (Pallas). Sanderling.

Rare spring and fairly common fall transient; sometimes seen during the summer. At Three Islands Whitman saw the species for the first time during the summer of 1934 on July 7. Moses has a male specimen taken at Nantucket Island on August 14, 1908.

110. *Himantopus mexicanus* (Müller). Black-necked Stilt.

Brewer (cf. Baird, Brewer and Ridgway[5], p. 346) remarked that "several individual birds have been taken at Grand Menan".

111. *Phalaropus fulicarius* (Linnaeus). Red Phalarope.

Rare transient, though sporadically common during the fall migration. Moses has a female specimen taken at Grand Manan on March 6, 1908, and a male specimen taken at Gannet Rock on June 3 (year not recorded). Whitman observed three during a trip to Machias Seal Island on August 15, 1934. Allen saw two solitary birds between Grand Manan and Machias Seal Island on August 20, 1929.

112. *Steganopus tricolor* Vieillot. Wilson's Phalarope.

Very rare visitant. Moses (cf. Legge[36], p. 56) saw one on March 6, 1909, the only time he has ever seen the species.

113. *Lobipes lobatus* (Linnaeus). Northern Phalarope.

Very common to abundant transient. In many of the areas of shallow water, particularly the shoals lying in the vicinity of the

Murr Ledges, the Northern Phalaropes congregate in enormous numbers during their migration. I collected one and saw several others on July 19, 1935, halfway between Grand Manan and the Murr Ledges. Whitman reported that a flock of "about seven hundred" spent most of the day of August 16, 1934, off the northern end of Kent's Island.

114. Stercorarius pomarinus (Temminck). Pomarine Jaegar.

Rare transient. "Common in autumn on the fishing grounds" (Herrick[11], p. 40). Moses (cf. Tuttle[47], p. 482) observed one capturing a phalarope near Grand Manan on May 26, 1911. Hickey and others observed an individual six miles northeast of Machias Seal Island on June 17, 1934.

115. Stercorarius parasiticus (Linnaeus). Parasitic Jaegar.

Fairly common transient. Herrick[11] (p. 40) speaks of it as follows: "Common fall visitant; comes about the fishing boats to pick up bits of bait, and is so tame that it is often killed with a gaff." Saunders saw one on August 22, 1926.

116. Stercorarius longicaudus Vieillot. Long-tailed Jaegar.

Very rare transient. Moses has a specimen taken at Long Pond Bay on October 4, 1923.

117. Larus hyperboreus Gunnerus. Glaucous Gull.

Uncommon to fairly common winter visitant. Moses has a specimen taken at Grand Manan on December 15, 1912.

118. Larus leucopterus Vieillot. Iceland Gull.

Fairly common winter visitant. A specimen in Moses' collection was taken on March 1, 1906.

Brewer[2] (p. 304) spoke of a few being found in the vicinity of White Head and "Two Islands" [=Outer and Inner Wood Islands] but the statement that they "breed on the same islands" is very much doubted. One wonders if Brewer did not observe nesting there several albino Herring Gulls such as the albino Herring Gull observed nesting at Kent's Island in 1932 (Whitman, MS).

119. Larus kumlieni Brewster. Kumlien's Gull.

Apparently very rare winter visitant. Moses possesses a male specimen taken at Grand Manan on February 10. 1916.

120. Larus marinus Linnaeus. Great Black-backed Gull.

Common summer resident, and fairly common winter resident. Moses[19] (p. 14) saw 100 on December 25, 1909. Joy saw about seventy-five at Kent's Island on January 10, 1936, and thirty on February 18, 1936.

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[47] Tuttle, *Auk*, 28, 482 (1911).

It is only within the last few years that this gull has been considered a common nesting species. Herrick[11] (p. 40) wrote that it "used to breed with the Herring Gulls, but being of a wilder nature it was the first to move in the direction of new and more secure breeding grounds". Townsend[42] (p. 142) saw "a few only" and said that Joy believed a pair recently bred at "Green Island". In July, 1933, Mayr found one pair nesting at Kent's Island. The following year Whitman reported four pairs nesting on Sheep Island but none on Kent's Island. In 1935, 1936, and 1937 ten pairs were estimated nesting on Three Islands. In 1936 and 1937 Joy found the first egg here on April 29.

121. *Larus argentatus smithsonianus* Coues. Herring Gull.

Very abundant summer resident and occasional winter resident. At Kent's Island Joy recorded the first Herring Gull in 1936 on February 25 and in 1937 on February 24.

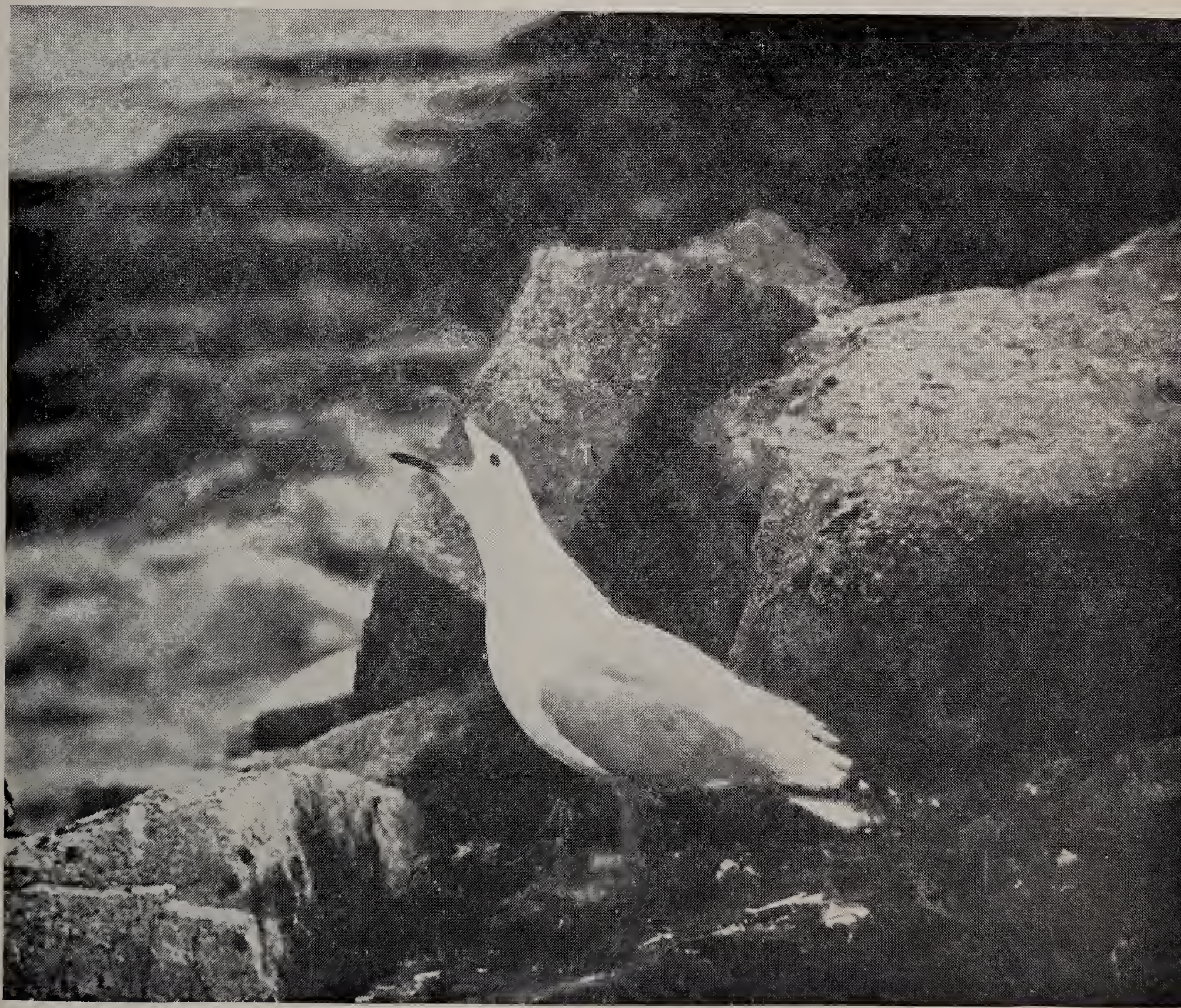
At Kent's Island Joy has found the first eggs of the year as early as May 12, 1936, and May 16, 1937. On May 24, 1935, A. O. Gross found over a hundred nests in the process of construction at Kent's Island. Three of them contained one egg each.

From 1935 to 1937 the breeding population of Herring Gulls in the Grand Manan archipelago has been broadly estimated in pairs to be 22,354 and is distributed among the islands as follows: Outer Wood Island, 800; Inner Wood Island, 100; Northern and Southern Green Islands, 4; Western Green Island, 700; the White Horse, 100; Three Islands, 20,000; Nantucket Island, 250; White Head Island, 400.

The Herring Gull once nested in great abundance at Southern Head, Grand Manan. Of this colony Herrick[11] (p. 40) wrote: "On the Southern Head is a very extensive nursery, and from the edge of the cliffs the eggs can be counted by the hundred, all the way down, until they grow indistinguishable in the distance." According to some of the older residents of Grand Manan the birds also nested on the more or less level terrain directly back from the cliffs, a place which was familiarly known as "Gull Heath". It was shortly after Herrick's visit, however, that foxes were introduced to Grand Manan and brought about the almost immediate disappearance of the Herring Gull as a nesting bird. (See introduction.) By 1883, so Joy relates, the Herring Gull no longer bred at Grand Manan.

Occasionally the Herring Gull has attempted to nest on some of the islands where it does not regularly do so. On June 17, 1891, Bent and Durfee found a nest containing one egg at the Yellow

A group of American Eiders at Kent's Island.



Herring Gull. Few Herring Gull colonies are larger than the one on Kent's Island.
Photographs by Alfred O. Gross.

Murr Ledge. On July 2, 1935, Lincoln Harvey found two nests with eggs on Gull Rock directly off the shore of Machias Seal Island.

When Audubon[1] (pp. 588-590) landed on White Head Island on May 23, 1833, he was greatly impressed with the fact that the nests were placed in trees and wrote at length on the subject. In his time undoubtedly White Head Island and many of the other islands were heavily wooded with spruce and the birds used these nesting sites for want of space on the ground. On Kent's Island at the present time a few Herring Gulls, perhaps three or four dozen pairs, can still be found nesting in trees, but the vast majority of them have resorted to the open surfaces of the island.

122. Larus delawarensis Ord. Ring-billed Gull.

Apparently an uncommon transient and rare winter visitant. Moses observed one bird on April 15, 1937, and has noted several others about this time in previous years. Herrick[11] (p. 41) considered the Ring-billed Gull common during migration.

Audubon[1] (p. 99) mentioned this bird [= "*L. zonorhynchus*"] as breeding on an island "close to Grand Manan", but his statement was never verified by any later observer.

123. Larus atricilla Linnaeus. Laughing Gull.

Very rare summer visitant. Moses has seen three Laughing Gulls during the late summer, one on the Castalia Marshes, one near Nantucket Island, and one at Low Duck Island. These individuals were observed between 1925 and 1930.

124. Larus pipixcan Wagler. Franklin's Gull.

Moses took a female at North Head on December 6, 1925. The identification of the specimen was subsequently confirmed by Taverner[48] (pp. 217-218).

125. Larus philadelphia (Ord). Bonaparte's Gull.

Probably a common transient and regular winter visitant. Allen saw one at Machias Seal Island on August 20. 1929.

126. Pagophila alba (Gunnerus). Ivory Gull.

"Winter visitant" (Herrick[11], p. 41). "Accidental; Grand Manan" (George A. Boardman, cf. S. L. Boardman[14], p. 314). Knight[35] (p. 135) wrote that a specimen had actually been taken by Boardman at Grand Manan. On December 31, 1908, Moses[19] (p. 15) saw one bird, the first and only one he has ever seen alive.

127. Rissa tridactyla tridactyla (Linnaeus). Atlantic Kittiwake.

Common transient and winter resident. Moses has two specimens taken at Grand Manan on January 4 and December 25. 1908. On

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[48] Taverner, *Auk*, **44**, 217-228 (1927).

December 30 of that same year he[19] (pp. 14-15) saw these birds at North Head "sitting in a white line" on the outlying water as far as he could see. Cruickshank saw eight of these birds at Machias Seal Island on July 21, 1935 Saunders observed them in the archipelago on August 19 and 31, 1926.

128. *Xema sabini* (Sabine). Sabine's Gull.

Casual visitant. Moses has observed but three birds, two in December about 1922 and one in August about 1926. All were seen in Long Island Bay.

129. *Gelochelidon nilotica aranea* (Wilson). Gull-billed Tern.

George A Boardman gave Deane[49] (p. 63) the record of a specimen shot at Grand Manan in the latter part of August, 1879, by one of his collectors.

130. *Sterna hirundo hirundo* Linnaeus. Common Tern.

Probably common transient; summer resident, nesting only on Machias Seal Island.

In July, 1932, I estimated approximately 50 pairs breeding on Machias Seal Island. According to Samuel E. Harvey, then keeper of the lighthouse, this number had remained fairly constant year after year. In July, 1937, I believed the number to be the same.

Formerly the Common Tern nested on some of the other islands of the archipelago. Bryant[7] (p. 120) stated that a "dozen pairs were breeding on the inner Green Island at Manan". In recent years Townsend[42] (p. 142) found a few breeding on "Green Island". The locality referred to in these records is undoubtedly Western Green Island.

131. *Sterna paradisaea* Brünnich. Arctic Tern.

Probably a common transient; summer resident, nesting on Machias Seal Island.

I estimated nearly 2,000 pairs of Arctic Terns nesting on Machias Seal Island in July, 1932. The number seemed to have remained the same during my visits in 1935 and 1937. Samuel E. Harvey informs me that the number of nesting terns has increased greatly during the past twenty years. When he first came to the island at the beginning of the century, there were not over a hundred pairs here. His earliest record for the Arctic Tern's appearance in the spring is May 1, 1932, while his two earliest records for eggs are May 13, 1935, and May 29, 1929. In 1937 Harvey E. Benson saw the first tern on May 6 and found the first egg on May 28.

Like the Common Terns, the Arctic Terns must have nested commonly elsewhere in the archipelago. Bent and Durfee saw "hundreds" of terns on the White Horse in 1891; two birds collected proved to be of this species. Joy tells me that the terns used to nest on all of the Three Islands and that the vast majority of them were Arctic Terns. Undoubtedly the Arctic Terns nested among the Common Terns that were reported nesting on Western Green Island.

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[49] Deane, *Bull. Nuttall Ornithol. Club*, 5, 63-64 (1880).

132. Sterna dougalli dougalli Montagu. Roseate Tern.

Apparently a rare summer visitant. Norton satisfactorily identified an individual flying across a portion of Machias Seal Island on June 24, 1931. Moses saw one in May near the outlying shoals called the "Bulkheads".

Sterna antillarum (Lesson). Least Tern.

Hypothetical. "Accidental; Grand Manan" (George A. Boardman, cf. S. L. Boardman[14], p. 314). This statement by Boardman is not substantiated by a specific record.

133. Hydroprogne caspia imperator (Coues). Caspian Tern.

Moses observed two birds at Whale Cove in April, 1925, and three others directly off Nantucket Island in August, 1930.

134. Chlidonias nigra surinamensis (Gmelin). Black Tern.

Apparently a rare transient, although Joy considers it fairly common in the fall. Moses has a female taken at the "Bulkheads" on May 29, 1911. Deane[49] (p. 63) wrote that three specimens were sent to George A. Boardman from Grand Manan. These birds were taken the latter part of August, 1879.

135. Rynchops nigra nigra Linnaeus. Black Skimmer.

Deane[50] (p. 243) said that George A. Boardman wrote him, under the date of August 31, 1879, that seven specimens had been killed off Grand Manan and Campobello Island. Moses has a female taken at White Island on October 24, 1924. Joy collected two near Inner Wood Island the same week.

136. Alca torda Linnaeus. Razor-billed Auk.

Common summer resident and probably rare winter resident.

While the Razor-billed Auk is frequently observed along the shores of many of the islands during the summer months, it is known to breed at the present time only on the Yellow Murr Ledge. I visited this colony on July 20, 1935, and estimated approximately a hundred pairs nesting here. Nearly all the eggs had hatched and I found one young bird with well-developed pin-feathers. Brownson[44] (p. 74) reported many eggs still unhatched on August 3, 1908

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[50] Deane, *Bull. Nuttall Ornithol. Club*, 4, 242-243 (1879).

When Whitman visited the ledge on August 16, 1934, no young were to be found although a small group of adults was observed. Allen saw but twelve birds here late in August, 1929. The Yellow Murr Ledge is one of the several so-called Murr Ledges. Herrick[11] (p. 41), and Pearsall[12] (p. 524) refer to this general area as the breeding ground of the species. From all appearances, however, the Yellow Murr Ledge is the only one which rises sufficiently high above the high-tide mark to permit the Razor-billed Auks to nest. It is highly probable the species has at one time or another nested on Machias Seal Island. In 1922 Samuel E. Harvey noticed an egg in the resident colony of Puffins which, from his description, seems to be unquestionably that of the Razor-billed Auk. During July, 1937, Razor-billed Auks were seen daily resting along the shore bordering the Puffin colony. Several times they were actually noticed to alight on the ledges in the midst of the colony; but none of them were ever seen to disappear among the crevices where the Puffins were nesting.

Plautus impennis (Linnaeus). Great Auk.

According to Herrick[11] (p. 41) the bones of this extinct bird have been dug up on Nantucket Island.

137. Uria aalge aalge (Pontoppidan). Atlantic Murre.

Rare transient and winter visitant. Moses has a male taken at Grand Manan on April 12, 1927, and another taken there on February 12, 1908.

138. Uria lomvia lomvia (Linnaeus). Brünnich's Murre.

Fairly common transient and winter visitant. Moses (cf. Legge[36], p. 56) saw one on March 31, 1909. He[19] (p. 14) saw two others on December 25, 1908. In Moses' collection are two specimens, a female taken at North Head on January 19, 1926, and a male taken at Grand Manan on February 1, 1908.

139. Alle alle (Linnaeus). Dovekie.

Irregularly common to abundant transient and winter resident. Moses (cf. Legge[36], p. 56) saw one on May 4, 1909. He[19] (p. 13) saw a "great many" on December 22, 1908, and (ibid., p. 14) reported them "very plentiful" on December 26, 1908. Moses has two females in his collection, one taken on January 11, 1908, and the other taken on January 12. 1926.

140. Cepphus grylle grylle (Linnaeus). Black Guillemot.

Common resident.

On the small islands of the archipelago the following numbers of pairs have been estimated as breeding in 1936: Inner Wood Is-

Razor-billed Auks. A small colony of these shy sea birds is found each year on the Yellow Murr Ledge.

Atlantic Puffin. Two puffin colonies are to be observed south of the Maritime Provinces —one is on Machias Seal Island.

Photographs by Alfred O. Gross.

land, 6; Outer Wood Island, 300; Northern and Southern Green Islands, 80; the White Horse, 10; Kent's Island, 70; Sheep Island, 20; Western Green Island, 2. On the western shore of Grand Manan and at Northern and Southern Heads there are innumerable crevices in the giant cliffs which appear to offer suitable nesting sites for the Black Guillemot. While no estimations have ever been made, it is probable that several hundred pairs nest in this extensive area. In the vicinity of "The Southern Cross" near Southern Head I estimated 25 breeding pairs. Townsend[42] (p. 142) found nearly "twenty or thirty" birds near "The Bishop" at Northern Head and implied that they were breeding.

According to Joy the Black Guillemot first appears in the vicinity of the breeding grounds at Kent's Island about March 12. Not until the first part of April do they leave the water and come up onto the rocks under which they nest. In 1937 Joy noted the first bird on the breeding grounds on April 8. Joy's earliest record for eggs at Kent's Island is June 4, 1936. I found eggs present in the Outer Wood Island colony on June 7, 1935. The eggs in one set collected were found to be fresh. Several newly hatched young were present in the Kent's Island colony on July 11, 1935. Townsend[42] (p. 142) found eggs still present at Outer Wood Island on July 30, 1923, but most of them had hatched and some of the young were "fairly well grown".

141. Fratercula arctica arctica (Linnaeus). Atlantic Puffin.

Common summer resident in the vicinity of Machias Seal Island. Elsewhere in the archipelago the Puffin is infrequently seen for the bird seldom wanders more than three or four miles from its breeding grounds.

In 1932 and 1935 I estimated approximately 400 pairs nesting among the ledges and loose rock on the southwestern portion of the island. In 1937 I believed that at least a hundred more pairs were nesting there for the colony had expanded to include a number of rocks which had been vacant the years before.

Samuel E. Harvey tells me that the Puffins usually arrive in the vicinity of Machias Seal Island about April 20. In 1937 the first bird was seen on April 14. Generally they do not alight on the rocks of their breeding grounds until May 1. When I visited the island on June 3, 1935, the birds were nesting and I saw three eggs altogether. Whitman found that the Puffins were through nesting for the most part on August 15, 1934. although he was able to capture five well-grown young about ready to leave their nests.

Two lighthouses were built on Machias Seal Island in 1832. They were in operation until 1905 when they were replaced by the

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[51] Dutcher, *Auk*, 21, 97-208 (1904).

present one. According to Harvey, the keepers of the old lighthouses disliked the hundreds of Puffins and other birds nesting on the island and proceeded to drive them away. Harvey's statement is substantiated by further evidence. About 1883 Everett Smith, as reported by Norton (cf. Dutcher[51], p. 160) found only sixty birds on the island. Later, in 1903, Norton (cf. Dutcher, ibid.) reported three hundred birds present. The keepers of the new lighthouse, however, have been sympathetically disposed toward the birds with the result that the Puffin colony has increased in numbers considerably.

142. Zenaidura macroura carolinensis (Linnaeus). Eastern Mourning Dove.

Rare transient and summer resident. One was seen by Joy at Kent's Island on April 26, 1936. Moses has a female taken at Grand Manan on October 21, 1921. He flushed one from a road at North Head on July 9, 1935. On July 15, 1935, I heard one individual along the Grand Harbour Brook. Whitman and Fisher watched one feeding at Kent's Island on August 8, 1934. Joy's latest record for Kent's Island is November 1, 1936.

Ectopistes migratorius (Linnaeus). Passenger Pigeon.

Of the occurrence at Grand Manan of this now extinct species Herrick[11] (p. 36) wrote: "Not rare; said to breed in the interior of the island."

143. Coccyzus americanus americanus (Linnaeus). Yellow-billed Cuckoo.

Transient and very rare summer resident or visitant. Moses has a specimen taken at Grand Manan on September 30, 1930. Joy once observed the bird at Three Islands in September, 1934.

144. Coccyzus erythropthalmus (Wilson). Black-billed Cuckoo.

Fairly common summer resident. I observed the species at Castalia on June 14, 1935, and again along the Grand Harbour Brook on July 15, 1935. Allen recorded it on August 14, 1929. An individual was captured and banded by members of the Bowdoin Scientific Station at Kent's Island on August 21, 1936.

On July 10, 1872, Herrick[11] (p. 35) took a nest containing three fresh eggs. Moses found a nest at North Head several years ago.

Otus asio (Linnaeus). Screech Owl.

Hypothetical. Herrick[11] (p. 35) included the Screech Owl [="*Scops asio.* Mottled Owl"] in his list of Grand Manan birds and said: "Common; breeds." While there is nothing improbable in a Screech Owl having wandered northward to the archipelago, it is most unlikely that it has ever established itself sufficiently to be considered common. Certainly the extensive coniferous forests of Grand Manan are wholly unsuited to the species.

145. Bubo virginianus (Gmelin). Great Horned Owl.

A rare resident or visitant, though probably more common than the records show. Joy noted the bird once on Three Islands in January, 1933.

146. Nyctea nyctea (Linnaeus). Snowy Owl.

Irregularly rare to common fall and winter visitant. Moses has a specimen taken at Grand Manan on December 1, 1926, and another taken at Duck Island on December 20, 1922. Deane[52-54] and A. O. Gross[55] have reported many birds occurring here during the late fall and winter months. The earliest fall bird is that reported to Deane[52] (p. 10) by S. F. Cheney as being seen on October 20, 1876.

147. Surnia ulula caparoch (Müller). American Hawk Owl.

Rare visitant. On August 23, 1926, Saunders saw one in a brushy open space about halfway between Whale Cove and the fog whistle at Long Eddy Point.

Scotiaptex nebulosa (Forster). Great Gray Owl.

Hypothetical. "Occurs in winter" (Herrick[11], p. 35). While it is quite possible that this owl may occur as a winter visitant, Herrick's statement is not confirmed by records.

148. Asio wilsonianus (Lesson). Long-eared Owl.

Resident, probably fairly common. Moses has a male taken at North Head on March 27, 1908. Elmer Wilcox ran over a specimen with his car late in the summer of 1930. He now has it mounted.

149. Asio flammeus flammeus (Pontoppidan). Short-eared Owl.

Rare resident. Moses has a male taken November 19, 1908.

Bryant[7] (p. 115) wrote that J. E. Cabot found a nest of this bird "in the midst of a peaty bog...built on the ground, in a very slovenly manner, of small sticks and a few feathers, and presented hardly any excavation." It contained four eggs. Herrick[11] (p. 35) secured a set of eggs from White Head Island.

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[52] Deane, *Bull. Nuttall Ornithol. Club*, 2, 9-11 (1877).
[53] Deane, *Auk*, 19, 271-283 (1902).
[54] Deane, *Auk*, 23, 283-298 (1906).
[55] Gross, A. O., *Auk*, 44, 479-493 (1927).

150. Cryptoglaux funerea richardsoni (Bonaparte). Richardson's Owl.

Rare resident. Townsend[56] (p. 131) observed one near North Head on August 7, 1924. Moses has a specimen, a male, taken near North Head on November 15, 1907.

On April 11, 1924. Tufts[57] (pp. 85-86) discovered a nest containing five eggs on "one of the smaller islands" of the Grand Manan archipelago.

151. Cryptoglaux acadica acadica (Gmelin). Saw-whet Owl.

Resident, probably, fairly common. Moses has a male taken at White Head Island in March, 1921.

Tufts took a set of fresh eggs at Grand Harbour on April 17, 1932.

152. Antrostomus vociferus vociferus (Wilson). Eastern Whip-poor-will.

Rare transient and probably rare summer resident. One male was picked up dead at Gannet Rock on May 22, 1935, and given to Moses who now has it mounted. Clifford Morse told me that he heard one calling at Castalia on June 25, 1935.

153. Chordeiles minor (Forster). Nighthawk.

Common transient and fairly common summer resident; "breeds", according to Herrick[11] (p. 34). I heard one individual at Seal Cove early in the evening of June 6, 1935, and saw another at Woodward's Cove during the noon of June 12, 1935. Allen saw nine flying southward August 14, 1929. Saunders noted the species in migration between August 29 and September 4, 1926.

154. Chaetura pelagica (Linnaeus). Chimney Swift.

Uncommon transient and summer resident; probably breeds. I saw my first and only Chimney Swift at Grand Manan on June 1, 1935. Saunders saw a few on August 14, 1929, but none afterwards. An individual was captured and banded at Kent's Island on August 23, 1936.

155. Archilochus colubris (Linnaeus). Ruby-throated Hummingbird.

Rare transient and summer resident. I took one male at North Head on June 14, 1935, and observed the bird three times during the summer of 1935. Saunders saw one at Grand Manan on August 27, 1926, and W. A. O. Gross and Favour saw one at Kent's Island on August 28, 1934.

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[56] Townsend, *Auk*, 42, 131-132 (1925).
[57] Tufts. *Canad. Field-Nat.*, 39, 85-86 (1925).

156. *Megaceryle alcyon* (Linnaeus). Belted Kingfisher.

Transient and irregularly rare summer resident. One of the surprises of my work in the Grand Manan archipelago was that I did not observe the Kingfisher. Allen saw one at Dark Harbour on August 22, 1929, and Saunders saw another on August 31, 1926.

The only time Moses has ever known the Kingfisher to breed was when he found a nest at Nantucket Island., Joy once knew of several birds nesting along the banks at Deep Cove.

157. *Colaptes auratus* (Linnaeus). Flicker.

Very common summer resident. Joy saw six at Kent's Island on April 1, 1936.

Lincoln Harvey found one nest containing seven eggs at Deep Cove on June 1, 1935. The eggs hatched two days later.

158. *Melanerpes erythrocephalus* (Linnaeus). Red-headed Woodpecker.

Moses has a specimen taken at North Head in June, 1918.

159. *Sphyrapicus varius varius* (Linnaeus). Yellow-bellied Sapsucker.

Probably rare transient and summer resident. Moses has one specimen taken at Grand Manan in 1908. I noted what was unquestionably sapsucker's work on several trees along the Grand Harbour Brook.

160. *Dryobates villosus* (Linnaeus). Hairy Woodpecker.

Common resident.

I found a nest containing young nearly ready to leave on June 18, 1935. It was located fifteen feet from the ground in a large white birch stump along the Seal Cove Brook.

161. *Dryobates pubescens* (Linnaeus). Downy Woodpecker.

Very common resident.

At Deep Cove on June 16, 1935, I located one nest containing two eggs. When I visited the nest again on June 29 the eggs had hatched. Another nest, presumably with young, was pointed out to me in the yard of George Brown at Seal Cove on July 1, 1935. The hole had been drilled in a clothesline post only three feet from the ground.

162. *Picoides arcticus* (Swainson). Arctic Three-toed Woodpecker.

"Not rare in winter; may breed on the back of the island in heavy timber where few persons ever go" (Herrick[11], p. 35). Bryant[7]

(p. 118) noted a pair at Grand Manan. Moses has a male taken at North Head on March 23, 1908.

163. *Tyrannus tyrannus* (Linnaeus). Eastern Kingbird.

Common summer resident. Although I found no nests, I invariably found individuals and pairs in cultivated areas and in the extensive open heaths. Norton saw one flying over the Yellow Murr Ledge on August 26, 1936.

164. *Tyrannus verticalis* Say. Arkansas Kingbird.

On July 7, 1937, I picked up a freshly killed male specimen at Machias Seal Island.

165. *Muscivora forficata* (Gmelin). Scissor-tailed Flycatcher.

Moses has a specimen taken at North Head on October 26, 1924.

166. *Myriarchus crinitus boreus* Bangs. Northern Crested Flycatcher.

Apparently rare visitant or transient. I heard what I believed to be a Crested Flycatcher along the Dark Harbour road on June 11, 1935. Moses (Whitman, MS) observed an individual which stayed around the fields at Kent's Island during the month of June, 1933. He has a female collected at North Head on December 7, 1928.

167. *Sayornis phoebe* (Latham). Eastern Phoebe.

Rare transient and apparently rare summer resident. Moses took one male on April 11, 1922.

On June 18, 1935, I discovered one Phoebe in back of a barn at Seal Cove, and continued to find it there on successive visits until the middle of July. Undoubtedly the bird was nesting somewhere in the vicinity.

168. *Empidonax flaviventris* (Baird and Baird). Yellow-bellied Flycatcher.

Common summer resident in the heavily wooded areas.

I found a nest in the process of construction near the Dark Harbour road on June 8, 1935. Six days later one egg was noted in the nest while a broken egg was observed nearby. My next visit on June 21 found four eggs present. I watched three young leave this nest on July 13. In the woods bordering Watt Pond I found another nest with four fresh eggs on June 28, 1935. Other nesting records for Grand Manan are as follows: One nest with four eggs found on June 10, 1878 (Osborne[58], p. 187); two nests with four fresh eggs found on June 19, 1878 and June 20, 1878, respectively

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[58] Osborne, *Bull. Nuttall Ornithol. Club*, 3, 187-188 (1878).

(Pearsall[12], p. 524). Brewer (cf. Baird, Brewer, and Ridgway[4] p. 379) found a nest at Grand Manan "about two feet from the ground, placed in the fork of the bush [alder], and bearing a close resemblance to the nest of *Cyanospiza cyanea*." It seems very likely, in view of our present knowledge of the Yellow-bellied Flycatcher's habitus, that the nest which Brewer described was that of the Alder Flycatcher. I know of no instance of the Yellow-bellied Flycatcher placing its nest off the ground in this manner.

169. Empidonax trailli trailli (Audubon). Alder Flycatcher.

Common summer resident in the bushy marshes. At Machias Seal Island Norton saw one on August 27, 1936.

I found one nest containing three eggs on June 28, 1935. The eggs hatched on July 10. Mayr found two pairs at Kent's Island in July, 1933.

170. Empidonax minimus (Baird and Baird). Least Flycatcher.

Apparently rare summer resident. Moses collected a male at North Head on June 13, 1935, the first and only individual he has ever observed in the archipelago. I saw one at Castalia on July 2, 1935. Allen heard one at Grand Manan on August 24, 1929.

171. Myiochanes virens (Linnaeus). Wood Pewee.

Rare transient, possibly rare summer resident. I heard two along the Dark Harbour road on June 6, 1935. Bent and Durfee noted one at Nantucket Island on June 8, 1891.

172. Nuttallornis mesoleucus (Lichtenstein). Olive-sided Flycatcher.

Fairly common transient. I observed the Olive-sided Flycatcher on several occasions from June 5 to 17, 1935, but did not note it later in the season. I have the following additional records: one at Kent's Island, June 6, 1936 (Joy); one at Woodward's Cove, June 11, 1891 (Bent); one at Grand Manan, August 28, 1926 (Saunders).

I have no evidence of the species breeding in the archipelago.

173. Otocoris alpestris (Linnaeus). Horned Lark.

Transient.

Moses has two specimens taken on March 22 and 26, 1908, which seem, on superficial examination, to be definitely referable to *O. a. alpestris*, the so-called Northern Horned Lark. Two others taken on March 16, 1908, appear to be *O. a. praticola*, the so-called Prairie Horned Lark. Moses considers the former to be a rare transient at Grand Manan, the latter a fairly common transient.

174. *Iridoprocne bicolor* (Vieillot). Tree Swallow.

Abundant summer resident. Joy's earliest record for Kent's Island is that of two birds seen on April 1, 1936.

The Tree Swallow takes good advantage of the many nesting boxes provided by the human residents of the archipelago. Nine out of sixteen boxes were occupied in one door-yard at Seal Cove. Two pairs nested at Machias Seal Island in 1935. They took possession of their boxes as early as June 1. Several years ago 69 swallow houses were erected on Kent's Island by J. Sterling Rockefeller. In 1933 Mayr estimated that 48 of these houses were occupied by pairs of swallows; in 1934 Whitman estimated that 56 of these houses were similarly occupied. My earliest nesting date is that of three young nearly ready to leave the nest on June 21, 1935. These birds were located in an old woodpecker hole in a dead birch tree about ten feet from the ground. In 1856 Bryant[7] (p. 115) found it nesting abundantly in hollow stumps.

175. *Riparia riparia riparia* (Linnaeus). Bank Swallow.

Fairly common summer resident.

At Red Head Point on June 18, 1935, I located one small colony of five pairs. For some undetermined reason the Bank Swallows have decreased markedly at Grand Manan during the last few years. Five years ago nearly a hundred pairs nested in the gravel banks bordering the coast at Deep Cove as well as at Red Head Point. In 1935 the Red Head colony was the only one noted at Grand Manan. Even the large Kent's Island colony which Mayr estimated as containing slightly less than thirty-one pairs in 1933 diminished by 1935 and 1936 to a number estimated as only twenty-five pairs.

176. *Hirundo erythrogaster* Boddaert. Barn Swallow.

Abundant summer resident. Joy's earliest date for Kent's Island is May 3, 1937; his latest is November 9, 1935.

The peculiar structure of many of the smokehouses in different parts of the archipelago seems to have encouraged large numbers of Barn Swallows to nest. In these buildings the apices of the roofs are open and covered with superimposed roofs. Through these openings the birds gain admittance to the otherwise closed building and place their nests on the roof supports and the fish racks. In one smokehouse I noted six occupied nests. Mayr estimated forty-one pairs nesting in the deserted smokehouses and sheds at Kent's Island in 1933 and Whitman counted twenty-six pairs there in 1934. At Machias Seal Island in 1937 I found one pair nesting under a high porch floor, another in a hencoop, and eight others in the boathouse. At this same island on June 24, 1931, Norton found the nest of a Barn Swallow in a "playhouse" made of a large wooden crate. The nest was on a shelf for doll's dishes, four feet from the floor of the "house".

177. *Petrochelidon albifrons* (Rafinesque). Cliff Swallow.

Abundant summer resident.

Unfortunately the eaves of the smokehouses do not run over the sides of the buildings sufficiently to provide suitable nesting sites. Nevertheless the bird makes use of the generous eaves on barns and dwelling houses. Mayr estimated twenty-one pairs nesting on Kent's Island in 1933 while Whitman estimated twenty-five pairs in 1934. In 1856 Bryant[7] (p. 115) found the Cliff Swallow the most abundant swallow at Grand Manan.

178. *Progne subis subis* (Linnaeus). Purple Martin.

Rare transient and irregular summer resident. Moses took one at North Head on April 10, 1909, and saw another, probably a straggler, on July 5, 1935. Bent recorded one at North Head on June 14, 1891.

Brownson[44] (p. 77) reported a colony flourishing at North Head in August, 1908. I knew of no colony on Grand Manan in 1935.

Perisoreus canadensis (Linnaeus). Canada Jay.

"Not rare in winter: it may breed in the thick woods and swamps, but was not noted." This statement by Herrick[11] (p. 34) has not been confirmed by any other authority. While a few individuals of this typically Canadian species might be expected as residents, it should be considered hypothetical until definite records are obtained.

179. *Cyanocitta cristata cristata* (Linnaeus). Northern Blue Jay.

Rare transient and resident. "Common, breeds" (Herrick[11], p. 34). Joy saw one at Kent's Island on May 19, 1936, and May 23, 1937. Moses has seen the Blue Jay but rarely. He has a male taken at North Head on September 16, 1908. I heard one while walking along the Dark Harbour road,—my only personal record of its occurrence.

180. *Corvus corax principalis* Ridgway. Northern Raven.

Uncommon resident.

At Kent's Island Joy has the following nesting records: A nest with four eggs high up in a spruce tree, March 24, 1936; a nest with five eggs located on a ledge, April 7, 1937: a nest with three well-grown young located on a ledge, May 30, 1935. Herrick[11] (p. 33) found a nest on Outer Wood Island on June 12, 1872. In it were "four fully fledged young". Edward Kniffe gave me a young bird which he shot while it was flying past his home at Deep Cove on June 20, 1935.

Andros[38] (p. 151) indicated that the Raven bred on the cliffs at North Head and along the western coast. While there are many ideal localities for the nests of this form, no records have ever been obtained in recent years. It is unlikely that the Raven now nests anywhere on Grand Manan.

181. Corvus brachyrhynchos brachyrhynchos Brehm. Eastern Crow.

Very common resident.

My earliest breeding record is that of a nest which I found at Deep Cove on June 1, 1935, with three young approximately eight or nine days of age.

182. Penthestes atricapillus atricapillus (Linnaeus). Black-capped Chickadee.

Common resident.

An early nesting record is that of three eggs which I found in a knot hole of a telephone pole at Seal Cove on June 4, 1935.

183. Penthestes hudsonicus littoralis (Bryant). Acadian Chickadee.

Common resident. I found the Acadian Chickadee to occur as commonly in the archipelago as the Black-capped; in certain of the more heavily wooded areas the Acadian seemed even commoner.

On June 22, 1935, Mrs. Pettingill[59] (p. 279) found a nest at Deep Cove containing seven newly hatched young. I located another nest with young at Castalia on June 21, 1935. I collected one young bird well able to fly at Grand Harbour on July 15, 1935.

184. Sitta carolinensis carolinensis Latham. White-breasted Nuthatch.

Rare to irregularly common transient, rare summer resident. Sweet and Floyd (Whitman, MS) found one of these birds on Kent's Island during July, 1933, and W. A. O. Gross observed a pair there on July 27, 1934. Allen found White-breasted Nuthatches "abundant" on Grand Manan between August 14 and 27, 1929.

185. Sitta canadensis Linnaeus. Red-breasted Nuthatch.

Fairly common transient and summer resident. I saw this species a number of times during my trips through the wooded sections of Grand Manan in 1935. I captured and banded two individuals that had wandered to Machias Seal Island on July 7, 1937.

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[59] Pettingill, E. R., *Bird-Lore*. 39, 277-282 (1937).

Pearsall[12] (p. 524) found "young, fully fledged".

186. Certhia familiaris americana Bonaparte. Brown Creeper.

Rare to irregularly common transient and winter resident; apparently quite common as a winter resident. Moses has two specimens taken at Grand Manan in 1908, one on April 18 and the other on April 20. Joy recorded Brown Creepers at Kent's Island during the winter of 1935-36, seeing as many as six in one day.

In 1933 Mayr found three pairs nesting at Kent's Island and the same number was recorded by Whitman in 1934. Oddly enough this species was not even noted at Kent's Island in 1935 nor did I observe the species anywhere in the archipelago that same year.

187. Troglodytes aedon Vieillot. House Wren.

Apparently very rare transient or visitant. Moses saw one at Nantucket Island in April, 1935. This constitutes his only record for the archipelago.

188. Nannus hiemalis hiemalis (Vieillot). Eastern Winter Wren.

Common summer resident.

On July 18, 1935, I came upon a family of Winter Wrens at Little Pond. I found only three young. From their behavior I judged that they had very recently left the nest.

189. Telmatodytes palustris (Wilson). Long-billed Marsh Wren.

On October 8, 1930, Moses and Brooks collected two Long-billed Marsh Wrens at Castalia. Brooks[37] (p. 71) has written concerning this interesting find as follows: "Two Marsh Wrens taken at a marsh on the shore near Castalia, Grand Manan, by Moses and me on October 8th are unlike anything I have seen of this species. They are very black and white birds most nearly resembling the form recently named *waynei* from North Carolina by Sprunt and Dingle. They are even darker than this form of which I have two September birds taken by A. T. Wayne. Compared with them my Grand Manan bird has a black crown with no lighter coronal stripe, a black dorsal area and a snow white lower surface and supercilium. Female in fresh post-juvenal plumage, wing 45, tail 38, tarsus 18, exposed culmen 13.5. These birds were migrant; frequenting marsh grass and not cat-tails and were the only ones of their kind seen. In a cat-tail swamp not far away a Long-billed Marsh Wren of the ordinary brown type as in Ontario birds was seen but not secured. Mr. Moses has never seen Marsh Wrens on Grand Manan previously and certainly none breed there."

190. Mimus polyglottos polyglottos (Linnaeus). Eastern Mockingbird.

Moses has three male specimens taken at Grand Manan, one at North Head on October 15, 1911, another at Seal Cove on November 2, 1926, and another at North Head on January 19, 1928.

191. Dumetella carolinensis (Linnaeus). Catbird.

Rare summer resident. One bird was noted several times by Moses in the vicinity of Whale Cove Marsh during the summer of 1935. Another was recorded by Whitman at Kent's Island on July 20, 1934.

192. Toxostoma rufum (Linnaeus). Brown Thrasher.

Very rare summer resident or visitant. Moses has seen the Brown Thrasher but twice in the archipelago, once at Kent's Island in June and once at North Head.

193. Turdus migratorius migratorius Linnaeus. Eastern Robin.

Very common to abundant summer resident; occasional winter resident. Joy's earliest spring date for Kent's Island is March 3, 1936. Moses[19] (p. 13) observed two individuals at Grand Manan on December 22, 1908.

A nest containing newly hatched young which Ronald Russell and I found at Deep Cove on June 1, 1935, appears to be the earliest breeding record.

194. Hylocichla guttata faxoni Bangs and Penard. Eastern Hermit Thrush.

Fairly common summer resident. The earliest record for Grand Manan is that of a specimen in Moses' collection taken on April 15, 1908, while the latest is that of an individual positively identified by Moses[19] (p. 13) on December 22, 1908.

Breeding records for the archipelago are as follows: Eggs, Grand Manan, May 26 (Chapman[60], p. 414); one nest with three eggs found by Lincoln Harvey and Ronald Russell at Deep Cove, June 8, 1935; one nest with three eggs found by Bent at Ross Island, June 10, 1891; one nest with four eggs found by Sirdar Ingalls along the Seal Cove Stream, June 17, 1935; a set of eggs received by Pearsall[12] (p. 524) taken August 3, 1877.

Chapman, *Handbook of Birds of Eastern North America*, D. Appleton-Century Co., New York, 1934, 2nd rev. ed., xxxvi+581 pp.

195. *Hylocichla ustulata swainsoni* (Tschudi). Olive-backed Thrush.

Common summer resident.

The following breeding records have come to my attention: A nest with four fresh eggs found by Durfee at Grand Manan, June 11, 1891; a nest reported under construction by Brewer[2] (p. 305) on "Duck Island", June 15, 1850, one egg later found in it on June 18; one nest with four eggs found by Bent at Woodward's Cove, June 20, 1891; one nest with three eggs reported by Herrick[11] (p. 29) as being taken on June 21, 1872.

196. *Hylocichla minima aliciae* (Baird). Gray-cheeked Thrush.

Probably a fairly common transient. A female specimen in Moses' collection taken at Swallow Tail lighthouse on May 26, 1908, appears referable to this subspecies. Several years ago Moses sent this particular individual to the Portland Society of Natural History where its identification was verified by Norton.

197. *Hylocichla fuscescens fuscescens* (Stephens). Veery.

Apparently a rare visitant. Moses has seen the Veery but three times in the archipelago. He has a specimen taken at Gannet Rock on June 10, 1910.

198. *Sialia sialis sialis* (Linnaeus). Eastern Bluebird.

Apparently the Bluebird has never been a common summer resident of Grand Manan. Herrick[11] (p. 29) considered it rare and its status is the same at the present time. Moses believes that it was once slightly more numerous, especially during the first part of the century, but it has never been common. Joy saw a Bluebird at Kent's Island on March 29, 1936.

During the breeding seasons of 1934, 1935, and 1936 Moses observed a pair nesting at North Head. This was the first breeding record he had obtained in the archipelago in nearly eighteen years.

199. *Oenanthe oenanthe leucorhoa* (Gmelin). Greenland Wheatear.

George A. Boardman (cf. S. L. Boardman[14], p. 300) wrote of two specimens being taken in the vicinity of the St. Croix River Valley. One of these birds, so he informed Knight[35] (p. 141), was actually secured at Grand Manan.

200. *Regulus satrapa satrapa* Lichtenstein. Eastern Golden-crowned Kinglet.

Common to very common summer resident.

Mayr estimated twenty-five pairs nesting at Kent's Island in

June, 1933. At Grand Manan Cheney (cf. Andros[61], p. 204) found a nest "on or about" June 1, 1887; it contained ten eggs. Bent examined a nest on June 12, 1891, that had been pulled down and the eggs, which were nearly ready to hatch, were broken. Pearsall[12] (p. 524) reported the finding of a nest containing three fresh eggs on June 15, 1878. At Dark Harbour on July 1, 1935, I saw an adult carrying food.

201. Corthylio calendula calendula (Linnaeus). Eastern Ruby-crowned Kinglet.

Common transient and apparently rare summer resident; not definitely known to breed. From the time of my arrival at Grand Manan until June 5, 1935, I found the species to be quite common; thereafter I did not observe it again. Sweet and Floyd (Whitman, MS) saw two at Kent's Island during the summer of 1933 while Favour found one there on June 30, 1934.

202. Anthus spinoletta rubescens (Tunstall). American Pipit.

Irregularly common transient. Moses has seen numbers of birds at various times during the spring and fall but his only definite record (cf. Legge[36], p. 56) is that of an individual seen on May 11, 1909.

203. Bombycilla garrula pallidiceps Reichenow. Bohemian Waxwing.

Apparently an irregularly rare winter visitant. Moses[19] (p. 13) saw one December 22, 1908, and reported that he had seen three birds this same winter and had two of them in his collection. Another bird, he said, was taken by his father "about fifteen years ago". At the present time Moses has one specimen in his collection, a male taken at North Head on December 5, 1908.

204. Bombycilla cedrorum Vieillot. Cedar Waxwing.

Common summer resident. I saw as many as a dozen feeding at one time in a spruce tree at North Head on June 14, 1935.

On June 28, 1935, I watched a pair busily constructing a nest in a willow tree at North Head.

205. Lanius borealis borealis Vieillot. Northern Shrike.

Irregularly rare to common transient; apparently rare winter resident. Joy saw one at Kent's Island on March 4, 1936. Moses collected one specimen at Grand Manan on November 13, 1908, and saw another[19] (p. 14) on December 29, 1908.

[61] Andros, *Ornithol. and Ool.*, 12, 203-204 (1887).

206. Lanius ludovicianus migrans Palmer. Migrant Shrike.

Apparently rare transient. Moses collected one at North Head in 1908 and has it in his collection.

207. Sturnus vulgaris vulgaris Linnaeus. Starling.

Rare to fairly common resident. Moses observed the first Starling on Grand Manan in the fall of 1924. He has one in his collection which he secured two years later on March 29.

I noticed one pair nesting in a small opening between the clapboards of the United Baptist Church at Seal Cove on June 4, 1935.

208. Vireo solitarius solitarius (Wilson). Blue-headed Vireo.

Very rare transient and summer visitant; may breed. Moses first saw a member of this species in the Grand Manan archipelago early in June, 1935. Later on June 29 I collected a singing male in the woods near North Head.

209. Vireo olivaceus (Linnaeus). Red-eyed Vireo.

Common summer resident; undoubtedly breeds. Hickey and others observed a transient individual at Machias Island on June 17, 1934.

210. Mniotilta varia (Linnaeus). Black and White Warbler.

Fairly common transient but rare summer resident. Moses took two at North Head on May 13, 1925, and has them mounted. I saw one in the woods along the Dark Harbour road on July 1, 1935.

Vermivora peregrina (Wilson). Tennessee Warbler.

Hypothetical. "Not rare; breeds" (Herrick[11], p. 30). Probably the Tennessee Warbler is a rare transient and summer resident at the present time. Although it should be seen at least during migration, Moses and Joy have never observed this warbler and know of no person who has.

211. Vermivora ruficapilla ruficapilla (Wilson). Nashville Warbler.

Fairly common transient and summer resident. I took one male at Castalia on June 5, 1935, and observed a number of other individuals in the many alder swales throughout Grand Manan. I heard one at Kent's Island on July 11, 1935.

212. Compsothlypis americana pusilla (Wilson). Northern Parula Warbler.

Fairly common transient and summer resident. I collected one at Deep Cove on June 10, 1935. This individual was seemingly migrating as I found it in a small spruce tree in open pasture country, an area entirely unlike the heavily wooded, boggy areas where I found them later in the summer. Moses has a specimen which he collected at Grand Manan on September 22, 1908.

213. Dendroica aestiva aestiva (Gmelin). Eastern Yellow Warbler.

Common transient and summer resident. On treeless and shrubless Machias Seal Island I saw four of these birds on June 3, 1935. Two were entrapped in a shed and easily caught. The migration of this bird as well as that of several other kinds of warblers noted here was still underway.

A nest which Moses kept under observation at North Head during the breeding season of 1935 contained a full clutch of eggs by June 4 Durfee found a set of four eggs at North Head on June 14, 1891.

214. Dendroica magnolia (Wilson). Magnolia Warbler.

Common transient and summer resident. Two males and one female were observed during migration on June 3, 1935, at Machias Seal Island. One of these birds was seen to take off over the water toward Grand Manan

The following breeding records have been obtained in the archipelago: Nest under construction at North Head, June 5, 1877 (Andros[62], p. 183); new nest ready for eggs at Ross Island, June 10, 1891, and another new nest at Grand Manan ready for eggs two days later (Bent); nest with four fresh eggs, June 12, 1878 (Pearsall[12], p. 524); two nests containing four eggs each, one nest containing three, and one nest with one egg, June 13, 1891 (Bent and Durfee); one nest with four eggs at Nantucket Island, June 18, 1891, and another nest with four eggs at Grand Manan, June 20, 1891 (Durfee); one nest with four eggs "with advanced embryos", June 27, 1872 (Herrick[11], p. 31). Norris[63] (pp. 177-178) described in detail twenty-four sets of eggs collected at Grand Manan.

215. Dendroica tigrina (Gmelin). Cape May Warbler.

Rare transient and apparently very rare summer resident. Moses has a male specimen taken at North Head on May 13, 1925, and another male taken at Nantucket Island on May 19, 1917. In the collection of the Philadelphia Academy of Sciences is a specimen taken at Grand Manan on June 29, 1872, by Herrick (Bond *in litt.*, 1936).

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[62] Andros, *Ornithol. and Ool.*, 12, 182-183 (1887).

[63] Norris ("J. P. N."), *Ornithol and Ool.*, 12, 177-178 (1887).

216. Dendroica caerulescens caerulescens (Gmelin). Black-throated Blue Warbler.

Probably rare to fairly common transient but rare summer resident. Bent and Durfee saw one at Nantucket Island on June 8, 1891.

On June 6, 1935, I observed two singing males in the deep woods along the Dark Harbour road. Two days later I found both birds still present and discovered a female. I collected one of these males which proved to have greatly enlarged gonads. On later visits made on June 14 and July 1, one singing male was still present and it seemed apparent to me that the species was breeding here.

217. Dendroica coronata (Linnaeus). Myrtle Warbler.

Common transient but only fairly common summer resident.

Pearsall[12] (p. 524) found young "fully fledged" on July 7, 1878.

218. Dendroica virens virens (Gmelin). Black-throated Green Warbler.

Very common transient and summer resident.

Bent and Durfee each found a nest containing four eggs on June 11 and 12, 1891, respectively. Capen[64] (p. 59) discovered a nest at Seal Cove with one egg on June 17, 1887, and two days later he found it to contain four. I came upon a nest with partially grown young near North Head on June 21, 1935, and found another nest with four eggs at Deep Cove on June 23, 1935. Norris[65] (pp. 52-53) describes the eggs from seven sets taken at Grand Manan, the earliest being two sets of four eggs each secured on June 14, 1885 and 1888, respectively.

219. Dendroica fusca (Müller). Blackburnian Warbler.

Rare transient; probably rare summer resident. Moses has a male specimen taken at Grand Manan on May 26, 1908.

220. Dendroica pensylvanica (Linnaeus). Chestnut-sided Warbler.

Rare transient and apparently very rare summer resident. In an extensive alder swale along the Dark Harbour road I observed one singing male on June 12 and July 16, 1935. Bryant[7] (p. 116) reported seeing only one pair at Grand Manan.

221. Dendroica castanea (Wilson). Bay-breasted Warbler.

Fairly common transient and summer resident.

On July 3, 1935, I found a nest containing six partially grown young. This was located eight feet up in a spruce tree beside the Grand Harbour Brook.

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[4] Capen, *Ornithol. and Ool.*, 13, 59-60 (1888).
[5] Norris ("J. P. N."), *Ornithol and Ool.*, 16, 52-53 (1891).

222. Dendroica striata (Forster). Black-poll Warbler.

Common transient and summer resident. Joy noted the bird's arrival at Kent's Island in 1937 on May 17.

The Black-poll is a common breeding warbler in the areas on Grand Manan and on the outlying islands where stunted conifers predominate. In 1933 Sweet estimated 134 pairs nesting on Kent's Island. As early as June 8, 1935, Joy found a nest with one egg at Kent's Island. Later on June 12 five eggs were noted in it. On Hay and Sheep Islands Andros[66] (p. 179) reported five nests found in an hour's search. Durfee secured a set of four eggs on Nantucket Island on June 10, 1891. Norris[67] (pp. 41-43) describes the eggs in seventeen sets collected on Grand Manan, the earliest set, containing five eggs, being taken on June 11, 1885.

223. Dendroica pinus pinus (Wilson). Northern Pine Warbler.

Rare to fairly common transient, but apparently only a very rare visitant in the summer. Whitman observed a male at Kent's Island on August 2, 1934. Saunders saw one at Grand Manan on September 3, 1926.

224. Dendroica palmarum hypochrysea Ridgway. Yellow Palm Warbler.

Common spring transient and probably less common in fall; not known as a summer resident. Moses (cf. Legge[36], p. 56) reported Yellow Palm Warblers common at Grand Manan after April 14, 1909. He has a specimen in his collection taken there on April 22, 1909.

225. Seiurus aurocapillus (Linnaeus). Oven-bird.

Common transient and summer resident.

On July 18, 1935, I found a nest containing four well-incubated eggs in a deep woods near the Dark Harbour road.

226. Seiurus noveboracensis (Gmelin). Northern Water-thrush.

Apparently rare transient and very rare summer visitant. On July 31, 1936, I examined an individual captured by members of the Bowdoin Scientific Station after it had entered a wharf house at Kent's Island. The bird was banded and liberated. For two days thereafter it was seen from time to time feeding in the Basin. Saunders saw an individual at Grand Manan on August 22, 1926.

The specimen captured at Kent's Island was clearly *S. n. noveboracensis*, being very yellowish below and having an unmistakable buffy line over the eye. Two specimens in Moses' collection, a female taken at Whale Cove on May 30, 1908, and a male taken at Grand Manan on September 9, 1908, are of a questionably yellowish hue and should be critically examined and compared with a large collection.

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[66] Andros, *Ornithol and Ool.*, 12, 179-180 (1887).

[67] Norris ("J. P. N."), *Ornithol and Ool*, 15, 41-43 (1890).

227. *Oporornis agilis* (Wilson). Connecticut Warbler.

During his visit to Grand Manan Brooks[37] (p. 71) "called up" a young bird in the woods at North Head and viewed it within ten feet.

228. *Oporornis philadelphia* (Wilson). Mourning Warbler.

Apparently a rare transient; not known to occur as a summer resident. Moses states that he has observed this species in recent years, once in the Whale Cove Marsh and five times on Kent's Island. These birds were observed during the migration period.

229. *Geothlypis trichas brachidactyla* (Swainson). Northern Yellow-throat.

Common transient and summer resident.

Carol Wilcox showed me a nest by the side of the road at Deep Cove on June 14, 1935. The nest contained three eggs and on the following day a fourth egg appeared. The eggs hatched on June 27.

230. *Wilsonia pusilla pusilla* (Wilson). Wilson's Warbler.

Rare, perhaps a fairly common transient at times; unknown as a summer resident. Moses has a male taken at Grand Manan on May 18, 1908. I observed one singing bird along the road to Dark Harbour on June 6, 1935.

231. *Wilsonia canadensis* (Linnaeus). Canada Warbler.

Apparently a very rare transient; unknown as a summer resident. Moses has seen but two migrating individuals in the archipelago.

232. *Setophaga ruticilla* (Linnaeus). American Redstart.

Common transient and summer resident.

I watched a female constructing a nest at Castalia on June 5, 1935. Andros[66] (p. 179) found a nest at Hay Island on June 11, 1887. It contained three eggs. Mrs. Pettingill discovered a nest at North Head on June 29, 1935, with three young about ready to leave.

233. *Passer domesticus domesticus* (Linnaeus). English Sparrow.

Once a common resident on Grand Manan and some of the larger outlying islands where dwellings occur, but now relatively scarce. I did not observe the English Sparrow in 1935.

234. Dolichonyx oryzivorus (Linnaeus). Bobolink.

Rare to fairly common transient but rare summer resident. Joy saw one at Kent's Island on May 23, 1937, and May 27, 1935. A single bird loitered for several hours in the grass at Machias Seal Island on July 7, 1937. Allen reported two seen at Grand Manan on August 19, 1929. Moses declares that the Bobolink was once a fairly common summer resident. He, as well as several other natives of Grand Manan, told of seeing the Bobolink occasionally in the open fields throughout the entire summer.

235. Sturnella magna magna (Linnaeus). Eastern Meadowlark.

Rare transient but not known to remain as a summer resident. Joy saw one at Kent's Island on March 26, 1937. Moses has two specimens in his collection at the present time. One was taken at North Head on April 26, 1926, and the other was taken at Grand Manan on October 23, 1908. Moses has seen two others, one in January several years ago and one in the spring of 1935.

236. Agelaius phoeniceus (Linnaeus). Redwing.

Joy saw one at Kent's Island on March 27, 1936. On June 29, 1935, I observed an individual in the Whale Cove Marsh. This bird was undoubtedly a straggler as I did not see it there before or after that date. A. O. Gross identified one at Machias Seal Island on August 27, 1936.

237. Icterus spurius (Linnaeus). Orchard Oriole.

Accidental visitant. Joy collected one specimen at Kent's Island in the late summer of 1929.

238. Icterus galbula (Linnaeus). Baltimore Oriole.

Rare transient and probably rare summer resident. Moses took a male at North Head on June 1, 1908. He has seen as many as three birds at one time on Three Islands and has known the species to remain all summer at North Head.

239. Euphagus carolinus (Müller). Rusty Blackbird.

Apparently rare to fairly common transient but not known to remain as a summer resident. Saunders saw one at Grand Manan on August 23, 1926. Joy recorded 300 at Kent's Island on October 21, 1935. The last one of that year was seen on October 30.

240. Quiscalus quiscula quiscula (Linnaeus). Purple Grackle.

On November 20, 1931, an adult male was collected at Kent's Island by R. Griffin and mounted by Moses who now has it in his collection. The specimen was temporarily loaned to Taverner[40]

(p. 142) who corroborated the identification. This is not only the first definite record of the subspecies in the archipelago but, according to Taverner, the first definite record of the subspecies in Canada.

241. Quiscalus quiscula aeneus Ridgway. Bronzed Grackle.

Common transient but rare summer resident. At Kent's Island Joy recorded the first bird seen in 1936 on March 19. Moses has two specimens taken at North Head on April 20, 1908. He observed a pair frequently back of his house at North Head during June, 1935. A wandering female specimen was taken at Machias Seal Island on July 13, 1937. Joy saw 75 at Kent's Island on November 1, 1925 and three more two days later.

Several years ago Moses found a pair nesting high up in a spruce at North Head.

242. Molothrus ater ater (Boddaert). Eastern Cowbird.

Fairly common transient, particularly in August; rare summer resident; no eggs have ever been noticed. Whitman saw one individual at Kent's Island on July 5, 1934, and collected one later on August 16. I saw two males at Machias Seal Island on July 7, 1937. Townsend[42] (p. 143) observed one male at North Head on August 7, 1923. Allen saw another at Machias Seal Island on August 29, 1929.

243. Piranga erythromelas Vieillot. Scarlet Tanager.

Rare transient and probably very rare summer resident. On June 3, 1935, I watched a female Scarlet Tanager resting on a fence rail at Machias Seal Island. Its wings were drooping noticeably, thus indicating that it had just completed a rather lengthy flight in its migratory journey.

244. Hedymeles ludovicianus (Linnaeus). Rose-breasted Grosbeak.

Rare transient and summer resident. On May 16, 1871, Herrick[11] (p. 32) took a male specimen. Moses has an unlabelled male specimen in his collection which, so he assured me, was taken at Grand Manan in the spring. On June 12, 1935, I heard one bird singing near the Dark Harbour road.

245. Guiraca caerulea (Linnaeus). Blue Grosbeak.

Herrick[11] (p. 32) wrote: "In the spring of 1861, Mr. Cheney shot a fine ♂ specimen and sent it to G. A. Boardman, Esq., in whose cabinet it now is." Later Knight[35] (pp. 139-140) stated that *two* specimens had been taken at Grand Manan, another apparently having been taken since Herrick's list was published.

246. Passerina cyanea (Linnaeus). Indigo Bunting.

Apparently rare transient and summer resident. Moses has a male specimen in his collection taken at Grand Manan on April 18, 1912. Bent heard one singing at North Head on June 14, 1891.

247. Hesperiphona vespertina (Cooper). Evening Grosbeak.

Apparently irregularly to fairly common winter visitant. In Moses' collection there is a male taken at Grand Manan on February 26, 1913.

248. Carpodacus purpureus purpureus (Gmelin). Eastern Purple Finch.

Fairly common transient and summer resident. Moses has a specimen taken at Grand Manan on May 2, 1922. I observed the bird three times during 1935.

249. Pinicola enucleator (Linnaeus). Pine Grosbeak.

An irregularly common winter visitant. Three specimens in Moses' collection were taken on January 15, 1923. At Kent's Island during the winter of 1935-36 Joy saw Pine Grosbeaks nearly every day from December 28 to March 20. The greatest number seen on any one day was twenty on February 2.

250. Acanthis linaria (Linnaeus). Redpoll.

Usually a fairly common winter visitant. Moses (cf. Legge[36], p. 56) has seen them as late as April 22, 1909.

The majority of birds seen in the archipelago are undoubtedly of the common form, *A. l. linaria*. Two specimens in Moses' collection, however, are obviously referable to the larger races. One, a male collected on December 24, 1908, has been identified by Moses and verified by Brooks [37] (p. 72) as *A. l. holboelli*, Holboell's Redpoll. The other, a specimen taken on March 9, 1926, is probably *A. l. rostrata*, Greater Redpoll.

251. Spinus pinus pinus (Wilson). Northern Pine Siskin.

Apparently an irregularly common resident. Moses has one specimen taken at Grand Manan on November 17, 1925. At Kent's Island Joy estimated seeing more than two hundred birds on November 7, 1935, and from then on during the winter he saw Siskins regularly.

Tufts reports having seen several sets of Pine Siskin eggs taken at North Head some years ago.

252. Spinus tristis Linnaeus. American Goldfinch.

Common transient and summer resident; undoubtedly nests.

253. *Loxia curvirostra* Linnaeus. Red Crossbill.

Apparently rare to fairly common resident. Moses has specimens taken on the following dates: Two, March 9, 1926; one, March 28, 1926.

254. *Loxia leucoptera* Gmelin. White-winged Crossbill.

Fairly common resident. Pearsall[12] (p. 524) saw a flock of about a dozen individuals on June 15, 1878. Moses[19] (p. 13) saw nineteen on December 22, 1908. During 1935 I did not see the species until July 15. From that date on I observed individuals frequently.

255. *Pipilo erythrophthalmus erythropthalmus* (Linnaeus). Red-eyed Towhee.

A male taken at Gannet Rock and now in Moses' collection is the only record for the archipelago.

256. *Calamospiza melanocorys* Stejneger. Lark Bunting.

Moses has a young male specimen taken at Nantucket Island on August 15, 1910[63] (p. 490).

257. *Passercules princeps* Maynard. Ipswich Sparrow.

Apparently a rare transient. Moses (cf. Legge[36], p. 56) recorded one bird on March 26, 1909. Moses has collected two specimens at Kent's Island, one of which was presented to Brooks[37] (p. 72). Joy saw one at Kent's Island on May 7, 1936.

258. *Passerculus sandwichensis* (Gmelin). Savannah Sparrow.

Very common transient and summer resident.

The earliest breeding record that has come to my attention is that of four eggs in a nest found by Joy at Kent's Island on May 29, 1935. The latest breeding record has been obtained by Carol Wilcox. He found five fresh eggs in a nest at Deep Cove on July 18, 1935.

Breeding birds in the archipelago are undoubtedly of the eastern race, *P. s. savanna*. During migration, however, both the eastern race and the dark-colored Labrador Savannah Sparrow, *P. s. labradorius*, should be expected.

259. *Ammodramus savannarum australis* Maynard. Eastern Grasshopper Sparrow.

Brooks[37] (p. 71) took a young male at North Head on October 1, 1930.

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[63] Dunham, *Auk*, 28, 490 (1911)

260. Ammospiza caudacuta (Gmelin). Sharp-tailed Sparrow.

Fairly common transient; summer resident in the Castalia Marshes. Moses has one male taken on October 6 (year not stated).

On July 10, 1935, I found a nest in the Castalia Marshes containing three newly hatched young, and one sterile egg. Earlier in the year on June 22 I came upon two nests which had been flooded by a recent high tide. These I determined to be of this form, having observed one pair at the nest with the use of a blind.

Birds breeding in the Castalia Marshes are *A. c. subvirgata*, the so-called Acadian Sparrows. Whether some of the birds seen in the archipelago during migration are *A. c. nelsoni*, has never been determined.

261. Pooecetes gramineus (Gmelin). Vesper Sparrow.

A rare to fairly common transient; not known as a summer resident. Joy reported small flocks of Vesper Sparrows at Kent's Island the last of September and the early part of October, 1935. Moses[19] (pp. 13-14) saw one bird at Grand Manan on December 21, 24 and 29, 1908.

262. Chondestes grammacus (Say). Lark Sparrow.

Of casual occurrence during the late summer and fall. Moses has two specimens in his collection taken at North Head on August 24, 1925. One is an adult female and the other is a young bird. Townsend[42] (p. 143) saw and collected one juvenile male at North Head on August 13, 1923. Three days later he saw two of these sparrows near Whale Cove and believed both of them to be immature. Brooks[37] (p. 71) took another at North Head on October 3, 1930.

While it is logical to assume that birds occurring in the archipelago are of the more easterly race, *C. g. grammacus*, Brooks (ibid.) states that the bird which he secured appears to be of the more westerly race, *C. g. strigatus*. He believes, too, that the two birds in Moses' collection are likewise referable to this race.

263. Junco hyemalis hyemalis (Linnaeus). Slate-colored Junco.

Common transient and summer resident; rare to fairly common winter resident. Moses[19] (p. 13) saw eleven birds at North Head on December 21, 1908.

My earliest breeding record is that of a young female well able to fly which I collected near Dark Harbour on June 12, 1935. On this same date a nest containing four eggs was found by Lincoln Harvey at Deep Cove. On July 18, 1935, I found a nest beside the Dark Harbour road with four newly hatched young.

264. Spizella arborea arborea (Wilson). Eastern Tree Sparrow.

Common transient and winter resident.

265. *Spizella passerina passerina* (Bechstein). Eastern Chipping Sparrow.

Rather rare transient and summer resident. I saw the Chipping Sparrow on two occasions only, once at North Head on June 14, 1935, and once at Castalia on June 30, 1935.

266. *Spizella pusilla* (Wilson). Field Sparrow.

Apparently fairly common transient but very rare summer resident. Joy recorded twenty at Kent's Island on October 14, 1935. On July 3 and 5, 1935, I observed one individual in a pasture at Grand Harbour. I found no evidence of its nesting.

267. *Zonotrichia leucophrys* (Forster). White-crowned Sparrow.

Fairly common transient.

The vast majority of transient birds are undoubtedly *Z. l. leucophrys*. Moses has a specimen taken at North Head on October 5, 1911. Brooks[37] (p. 72) believes that it shows more traces of *Z. l. gambeli* and he has, therefore, listed it as such.

268. *Zonotrichia albicollis* (Gmelin). White-throated Sparrow.

Common transient and summer resident.

On June 10, 1935, I found a nest at Deep Cove containing four fresh eggs. I observed two other nests later on June 14 and 18 at Dark Harbour and Seal Cove respectively.

269. *Passerella iliaca iliaca* (Merrem). Eastern Fox Sparrow.

Common transient. Joy saw ten at Kent's Island on March 24, 1936. Bent and Durfee found a body of a Fox Sparrow at the Yellow Murr Ledge on June 19, 1891. Moses[19] (p. 13) has observed one at North Head as late as December 20, 1908.

270. *Melospiza lincolni lincolni* (Audubon). Lincoln's Sparrow.

Rare transient and summer resident. Moses has two specimens taken at Grand Manan, one on May 2, 1922, and the other on May 26, 1908.

On June 28, 1935, Moses and I watched a pair along the shore of Watt Pond. Though both birds protested our presence vociferously, we were unable to find their nests or young. Bond[69] (p. 96) found at least two pairs in an open bog [=Castalia Marshes] during the latter part of June, 1933.

271. *Melospiza georgiana* (Latham). Swamp Sparrow.

Fairly common transient and summer resident.

On June 28, 1935, I observed a young bird well able to fly. This was at Watt Pond where several pairs of this species were probably nesting.

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[69] Bond, *Auk*, 52, 95-96 (1935).

272. Melospiza melodia (Wilson). Song Sparrow.

Common transient and summer resident; an occasional winter resident.

Breeding birds are *M. m. melodia.* Whether other races occur during migration and the winter months is a matter for further study.

273. Calcarius lapponicus lapponicus (Linnaeus). Lapland Longspur.

Apparently rare transient. Moses tells me that he has observed the Lapland Longspur several times among migrating flocks of larks and pipits but he has never succeeded in collecting it.

274. Calcarius ornatus (Townsend). Chestnut-collared Longspur.

Moses has a male specimen taken at Nantucket Island on June 2, 1914.

275. Plectrophenax nivalis nivalis (Linnaeus). Eastern Snow Bunting.

Common transient and winter resident. Moses has a specimen collected at North Head on November 17, 1935. In the winter of 1935-36 Joy recorded the first Snow Buntings at Kent's Island on December 28 and the last ones on March 11.

A PIPETTE FOR THE MICRO ESTIMATION OF RESPIRATORY GASES.

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(Received May 9, 1938).

ABSTRACT.

A pipette of new design is described for the estimation of carbon dioxide and oxygen in 0.2 ml. or smaller samples of gas. Procedures described include the use of saturated calcium chloride solution instead of mercury for work with carbon dioxide, and the use of chromous sulphate as an oxygen absorbent.

Introduction.

Gas analysis in the pipette to be described is carried out by drawing a small sample of gas into a capillary tube of uniform bore where its length is measured; the sample is then subjected to the action of a specific absorbent after which its length is again measured in the capillary, the diminution representing the proportion of the particular gas absorbed. Procedures for the estimation of carbon dioxide and oxygen are given but of course the apparatus would be equally suitable for any other gas for which a satisfactory absorbent is available.

Timiriazeff[1] was perhaps the first to apply the method to biological investigation. Krogh[2] constructed a tonometer on the same principle, which was later simplified and applied to a variety of uses by Jordan (see Jordan and Hirsch[3]). These pipettes have the common advantage, for certain experiments, of using less than 0.2 ml. of gas for a test, and in experienced hands all have about the same accuracy. The special advantages of the one here described are: (1) it is practically impossible to lose the analytical sample halfway through the test; (2) the danger of spoiling an experiment by adding an extra bubble of outside air to the test gas is virtually eliminated; (3) carbon dioxide is estimated with the same ease as oxygen, with comparable accuracy and without the use of mercury; (4) a supplementary procedure is described by means of which as many tests as desired may be made on portions of a single sample, e.g. of alveolar gas; (5) a new and convenient oxygen absorbent is used.

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[1] Timiriazeff. *Ann. d.sc.nat. Sér 7. Botanique*, 2, 111 (1885).

[2] Krogh. *Skand. Archiv f. Physiol.*, 20, 279 (1908).

[3] Jordan and Hirsch. "*Uebungen aus der vergleichenden Physiologie.*" Springer, Berlin, 1927, p. 27.

REAGENTS.

Approximately 0.4M violet chrom alum, $KCr(SO_4)_2.12 H_2O$, in 0.1 N sulphuric acid. This is most simply made up as follows. Dilute 1 ml. of concentrated H_2SO_4 to 350 ml. with water. In 250 ml. of this dissolve without heat 50 gm. of chrom alum. Keep cool, preferably in a refrigerator. If the reagent turns emerald green in colour discard it. The passage of this chromic salt through a Jones reductor reduces it to the chromous condition, making it an extremely effective oxygen absorbent. The application of the reagent to gas analysis is described by Stone[4] who states that it is 25 to 50 times as effective as other well-known oxygen absorbents, over which it possesses the additional advantage of lack of causticity. Like all oxygen absorbents it must be protected from air, and the technique described below overcomes this difficulty.

Amalgamated zinc, 20 mesh. The preparation as described by Stone and Beeson[5] is as follows. 480 gm. of 20 mesh granulated zinc are stirred in 200 ml. of 3N (25 percent) hydrochloric acid for 30 seconds. Then 200 ml. of 0.013 M mercuric chloride solution (10 ml. of a saturated solution at 25°C. diluted to 200 ml.) are added to the zinc acid mixture. Soon after the addition of the mercuric chloride the evolution of hydrogen practically ceases. The stirring is continued for 3 minutes longer, after which the amalgamated zinc is washed thoroughly by decantation with distilled water. 480 gm. of zinc is sufficient for the Alcoa modification of the Jones reductor; half this quantity suffices for the conventional model. Amalgamated zinc usually retains its reducing power indefinitely. Stone and Beeson state, however, that certain preparations, which at first were entirely satisfactory, suffered a loss of efficiency that could not be explained.

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[4] Stone. *Journ. Amer. Chem. Soc.*, 58, 2591 (1936).
[5] Stone and Beeson. *Ind. Eng. Chem., Anal. Ed.*, 8, 188 (1936).

An alternative oxygen absorbent which is satisfactory is Stokes reagent made by mixing the following saturated solutions in the order given.

30 per cent sodium potassium tartrate	5 parts.
40 " " ferrous sulphate	1 part.
60 " " potassium hydroxide	1 part.

For a series of tests it is convenient to make up about 100 ml. at a time and to store it in a glass stoppered cylindrical separatory funnel of 125 ml. capacity. Here the slimy mass which appears on the addition of the ferrous sulphate may be removed by repeated inversion after the potassium hydroxide is added. The oxygen in the separatory funnel is of course absorbed, but this does not matter. The absorbent is delivered from the funnel into the gas pipette. It is not necessary to cover the Stokes solution with a layer of oil, but agitation is avoided, and the last few ml. of solution which have changed colour are discarded. It will not keep over night.

Saturated calcium chloride solution. Dissolve, with heat, 500 gm. of $CaCl_2$ in 500 ml. water and acidulate with a drop of 10 percent hydrochloric acid. Cool and use the supernatent fluid. The merits of calcium chloride as a substitute for mercury in gas analyses have been discussed by Peters and Van Slyke[6]. In a gas pipette mercury is impracticable because it frequently runs out of the capillary when the apparatus is inverted, and because the capillary would have to be laboriously dried before every test. It is essential that the fluid used be one in which none of the gases in the mixture to be analyzed shall be soluble. Water can usually be used in contact with mixtures containing O_2 and N_2, which are not very soluble in it. Carbon dioxide, however, is so soluble in water that contact with respired air cannot be permitted for even a brief time without significant absorption of CO_2. If, however, the water

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[6] Peters and Van Slyke. "*Quantitative Clinical Chemistry.*" Williams and Wilkins, Baltimore, 1932, vol. 2, p. 85.

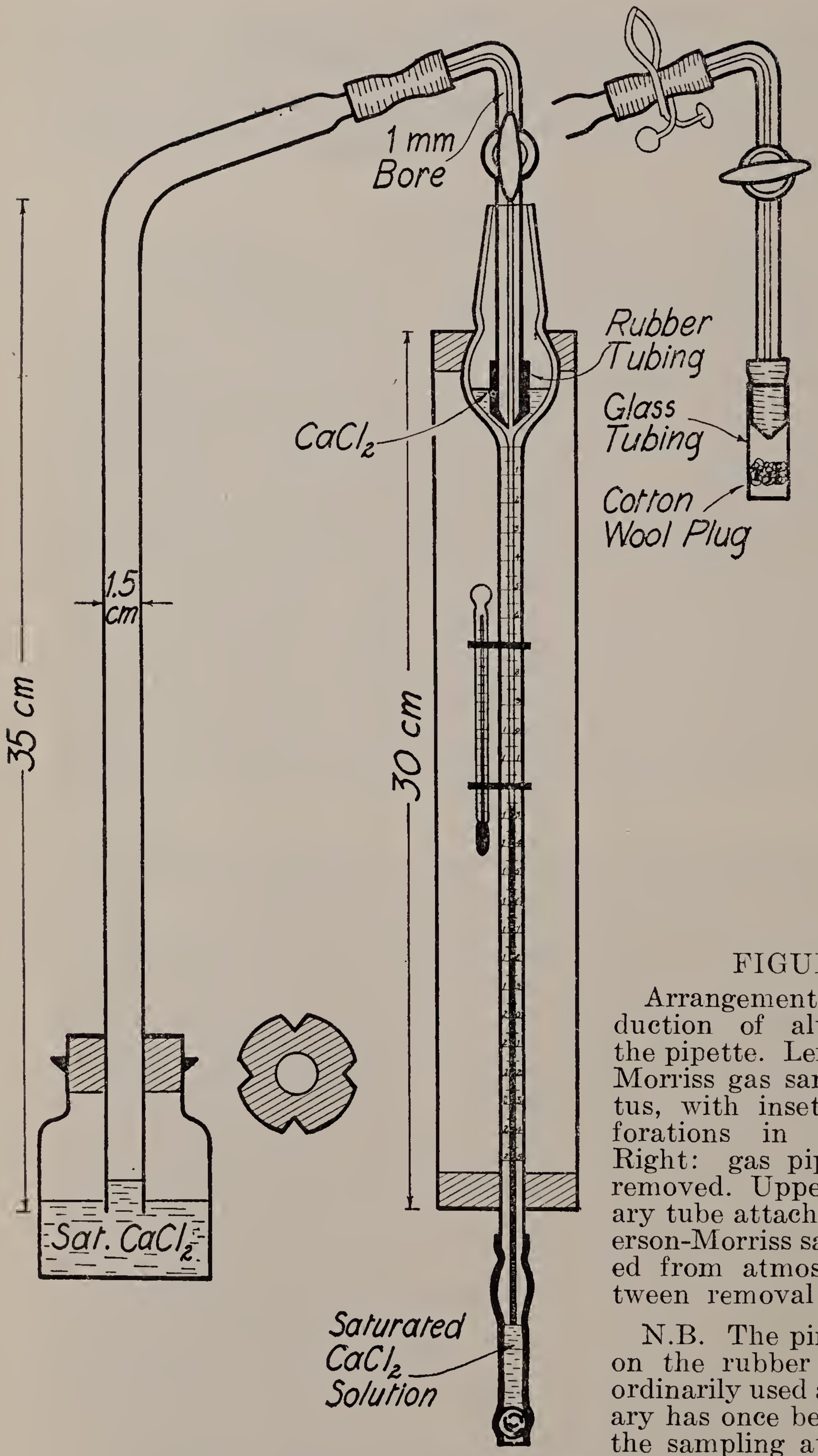

FIGURE I.

Arrangement for the introduction of alveolar gas to the pipette. Left: Henderson-Morriss gas sampling apparatus, with inset showing perforations in cork stopper. Right: gas pipette with top removed. Upper right: capillary tube attachment to Henderson-Morriss sampler protected from atmospheric air between removal of samples.

N.B. The pinchcock shown on the rubber tubing is not ordinarily used after the capillary has once been attached to the sampling apparatus.

is saturated with calcium chloride and slightly acidified, the solubility coefficient of CO_2 at room temperature is lowered from about 1.0 to 0.06. If the calcium chloride solution is brought into equilibrium with alveolar air, it can remain in contact with respiratory gases for days without measurable absorption of CO_2. This is the condition in the Henderson-Morriss apparatus after the first few samples have been taken.

Acetic acid, 5 per cent. This is used to wash the pipette after the use of alkaline solutions.

Two per cent sodium hydroxide. This is used as an absorbent for CO_2.

APPARATUS.

The gas pipette (Fig. I, II, III) consists of a capillary tube of 1 mm. bore, with a central portion 25 or 30 cm. long bearing 1 mm. graduations. To one end of the capillary is attached a short piece of rubber tubing, plugged with a glass bead. The other end is expanded into a chamber of 15-20 ml. capacity over which fits a top with ground glass joint of some 25 mm. diameter. (Standard Taper 24/40 is satisfactory). The top bears two capillary outlets with stopcocks each of which opens above into a chamber of 6-7 ml. capacity. These outlets (M and N of Fig. II and III) have a 2 mm. bore; they differ from one another in that capillary N extends some 4 cm. down into the chamber, while M has no such appendage. The pipette throughout most of its length is enclosed by a water-jacket containing a thermometer.

The alveolar gas sampler illustrated at the left of Fig. I is that of Henderson and Morriss[7]. It consists of a vertical tube of 50-100 ml. capacity held by a cork, from which segments have been removed, in a small wide-mouthed bottle containing a saturated solution of calcium chloride. The distal end of the tube projects just below the surface of the solution, and thus forms a Mueller valve. The other end of the tube is contracted to 7 or 8 mm. inner diameter and connects, by means of a piece of rubber tubing, either with a short glass mouth-piece (not illustrated), or with a delivery tube of 1 mm. bore pro-

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[7] Henderson and Morriss. *Journ. Biol. Chem.*, 31, 217 (1917).

vided with a stopcock. The rubber connection is closed by means of a pinchcock. The collecting tube should not project more than a few mm. beneath the surface of the calcium chloride solution, in order to avoid any serious obstruction to the flow of air. For the same reason the segments removed from the stopper must be large enough to afford, for the escape of air, openings totalling in area the cross section of the collecting tube.

The Alcoa modification of the Jones reductor is illustrated in Fig. II. A layer of glass wool is placed in the constricted end of the tube above the stopcock, and the tube filled with 20 mesh amalgamated zinc to make a column some 20 cm. or more in height. A thin layer of glass wool at the top completes the construction. When not in use the apparatus is filled with distilled water, several portions being used to rinse the zinc. The zinc column should be kept immersed at all times, the level of the fluid never being allowed to expose the top of the zinc, whether the apparatus is used or stored. If the zinc is allowed to become dry it is well to run 200 to 300 ml. of normal sulphuric acid through the apparatus before using it again. When

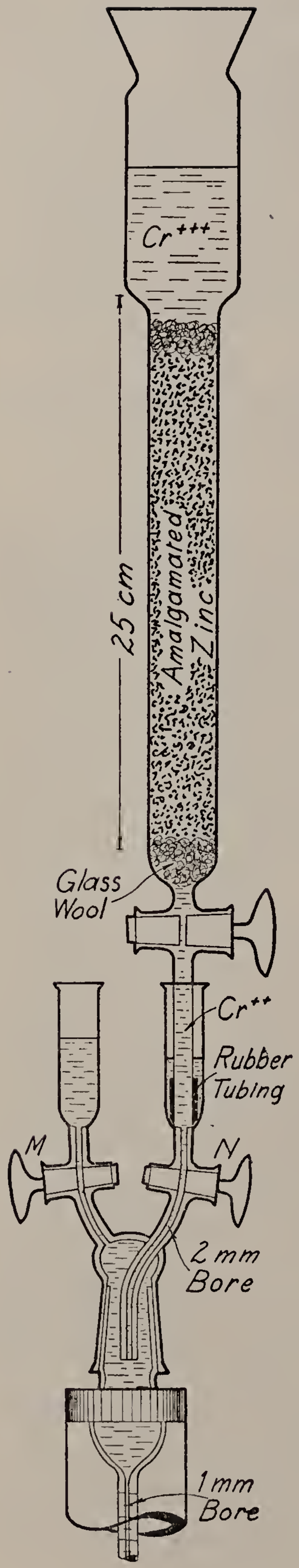

FIGURE II.

Arrangement for the introduction of oxygen absorbent to the pipette. Above: Jones reductor. Below: gas pipette with top attached and both stopcocks open.

N.B. The pipette at this stage is filled with water.

the apparatus is to be used the water in it is replaced by drawing chrom alum solution through until the chromous solution appearing at the bottom has reached a uniform blue tint. A little hydrogen which is liberated by use does not interfere with the operation of the reductor except to slow the rate of delivery somewhat, but it may be removed from the interstices of the zinc at the conclusion of a series of tests by attaching the reductor to a suction pump and pulling water through.

PROCEDURE.

I. The Collection of samples of respiratory gases.

Preliminary analysis of oxygen in atmospheric air. The pipette, with top and rubber tubing removed, is clamped vertically on a stand. The rubber tubing, whose end is closed by a glass bead, is filled with distilled water, slipped on the capillary, and the water column forced up the latter and into the bell. The pipette is now rotated to a horizontal position permitting the excess water in the bell to flow clear of the capillary opening, and by manipulation of the rubber tube a column of air about 20 cm. long is drawn in. The pipette is again placed vertically and 3 or 4 cm. of water drawn in on top of the column, after which the pipette is removed from the stand and laid horizontally on a table. The rubber tubing is moved until the ends of the air column are equidistant from the ends of the graduations, and the length and temperature recorded. Repeat several times, moving the column a little after each reading (see "Precautions" below). The pipette is now replaced vertically to the stand and the top put on. If chromous sulphate is to be used as an absorbent fill the bell with water through stopcock N; otherwise fill it up with Stokes solution and proceed with the absorption of oxygen. (Note. The CO_2 in atmospheric air amounts to only 0.03 per cent and may be neglected).

Carbon dioxide and oxygen in alveolar air. During a normal expiration the pinchcock at the top of a Henderson-Morriss sampler is opened, the mouth piece inserted between the lips, and the expiration prolonged forcibly. Just at the end of the expiration the pinchcock is closed. The respirations must remain natural throughout the procedure, and the tendency to catch a short breath just before the forcible expiration must be prevented. The expiration is made entirely through the mouth and at the end the pinchcock is closed sharply in order to prevent even the smallest inspiratory motion. The Mueller valve serves a double purpose. It prevents entrance of room air into the tube, and any inspiration at the beginning or end of the expiration can be detected by observation of the calcium chloride column in the tube.

The glass mouth piece, if one was used, is now removed from the rubber tubing, and the latter filled above the pinchcock with saturated calcium chloride solution. The stopcock of the capillary tube shown in Fig. I top right is opened, and the bent end inserted in the rubber tubing and pushed down to the pinchcock. This causes calcium chloride to displace air completely and drip out the end of the capillary, where it is prevented from becoming a nuisance by the glass tubing and cotton wool plug shown in Fig. I. The glass stopcock is now closed and the pinchcock removed from the rubber tubing, being of no further use in the test.

To prepare the gas pipette for the reception of a sample clamp it vertically on a stand with the top removed, fill the rubber tubing with calcium chloride solution and connect it. The capillary is now filled with solution and a little has run up into the bell. The capillary of the Henderson-Morriss apparatus, whose end is tapered to a cone and covered with thick-walled rubber tubing, is now inserted into the bell under the fluid surface in direct communication with the capillary of the pipette. A light downward pressure with the fingers makes a tight seal. By opening the stopcock and manipulating the rubber tubing of the gas pipette a column of alveolar gas 20 cm. long is slowly and steadily transferred to the capillary. The first sample is discarded by closing the stopcock, loosening the seal, and expelling the gas into the bell. The second or third sample is kept, the procedure being to close the stopcock, remove the alveolar sampling apparatus, pull down some 3 cm. of solution on top of the gas column, record the length with the pipette placed horizontally, and proceed with the analysis of CO_2. At least six tests can be made with one sample of alveolar gas, the limiting factor being the rising column of fluid in the tube above the bottle (Fig. I lower left). If one or two small droplets of calcium chloride get into the column of gas they can be readily measured and their length subtracted from the total.

Composition of the tracheal air of an insect. This experiment and the two following are suggested by von Buddenbrock and von Studnitz[8], whose directions are for oxygen estimation only, with the Jordan pipette. Invert the gas pipette with top removed, so that the bell dips beneath the surface of calcium chloride solution in a suitable vessel. Attach a piece of rubber tubing to the other end and suck through calcium chloride until the whole apparatus is filled. Close the rubber tubing with a screw clamp placed in the position occupied by the glass bead in Fig. I lower right. Now bring any large insect under the solution and quickly open the tracheal system so that the released bubbles float up into the bell. They are then drawn up into the capillary, the length recorded, and the analysis proceeded with.

The rate of oxygen utilization and respiratory quotient of insects. The pipette with top removed is clamped vertically to a stand, and the rubber tube filled with calcium chloride and attached. Any excess solution reaching the bell is carefully removed with filter paper, so that the solution just reaches the top of the capillary. Several small insects, e.g. flies, beetles, etc., are put in the bell, the top attached, and stopcocks M and N both closed. After several hours or next day, the pipette is tipped slightly and a little solution forced up into the bell. A column of gas is then withdrawn for analysis and sealed with solution by restoring the pipette to a vertical position. To make the experiment quantitative the insects are weighed and the volume of air in which they were confined is determined by filling the bell with water and emptying it out into a graduate.

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[8] von Buddenbrock and von Studnitz. "*Vergleichend-physiologisches Prakiikum.*" Springer, Berlin, 1936, p. 82.

The maximum utilization of oxygen by insects. Fill the capillary with 2 per cent sodium hydroxide solution, and allow a little to flow up into the bell. The insects are put in as before except that they are confined in wire gauze to prevent contact with the hydroxide. Continue the experiment until the insects are dead or obviously dying. Collect a sample as before and estimate the percentage of oxygen in it.

II. The Estimation of Carbon Dioxide.

Carbon dioxide is determined by absorbing it with sodium hydroxide and observing the decrease in the length of the column. Unfortunately sodium hydroxide and calcium chloride react to form a white precipitate and for this reason most of the latter is removed before the hydroxide is added. Rinse the bell twice with distilled water, attach the top with a seal of grease and fill the bell with water through stopcock N. Be sure that no bubbles are left either in the bell or capillaries of the top. Close stopcock M and with the pipette held as in Fig. III expel the gas into the bell. Leave stopcock N open and turn the pipette upright again, permitting the bubble to rise. Put a little water in the chamber above N and, by

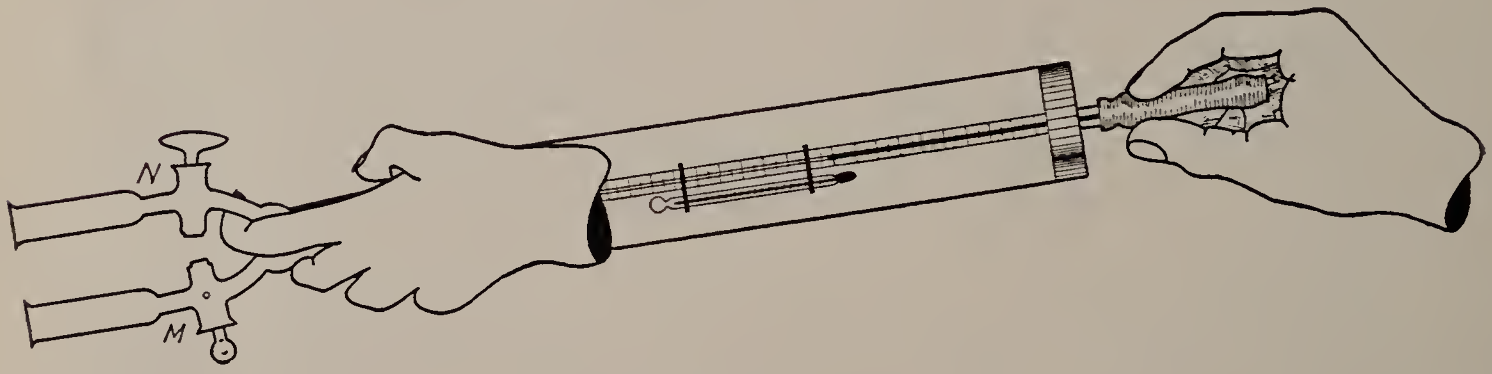

FIGURE III.

Position for expelling the column of gas from the capillary into the bell for absorption of CO_2 or O_2. Although cock N is open, ensuring atmospheric pressure inside at all times, the bubble cannot be lost. Cock M is closed. To withdraw the bubble into the capillary the pipette is inverted. Note that the bubble is manipulated by sliding the rubber tubing up and down rather than by squeezing it.

squeezing the rubber tubing, pump the calcium chloride solution out of the capillary into the bell, where it mixes with the water. Invert the pipette still leaving stopcock N open and withdraw the bubble into the capillary. The length diminishes by loss of about half of the CO_2 through contact with water. Open stopcock M, empty the apparatus and refill it with 2 per cent sodium hydroxide. Close stopcock M and, as in Fig. III, expel the gas into the bell. A slight turbidity due to precipitated calcium hydroxide does no harm. Keeping the same angle rotate the pipette for 10 seconds, then invert it and withdraw the gas into the capillary. Take several readings of the length and record the temperature. Repeat in order to make sure that all the CO_2 has been absorbed. This should produce no change in length. Open stopcock M and empty the apparatus leaving the gas in the capillary, protected from the air by some 3 cm. of fluid at the top.

III. The Estimation of Oxygen.

If chromous sulphate is to be the absorbent used, fill the pipette with water through stopcock N. Empty and refill with water. Close stopcock M and pipette off any water in the chamber above it. A little chrom alum is now passed through the reductor to clear out any oxygen in the tube below the stopcock. It is desirable, but not necessary, to have a column of fluid uninterrupted by air in this tube. One or 2 ml. of water is placed in the chamber above stopcock N and the delivery tip of the reductor brought into contact with the capillary as in Fig. II. A piece of rubber tubing over the tip of the reductor makes a seal which is maintained by the weight of the reductor. It is convenient to clamp the pipette and the reductor on the same stand. Open fully stopcock N and that of the reductor, and by manipulation of stopcock M permit the chamber above M to fill with displaced water. The 5 or 6 ml. of chromous sulphate introduced in this way is adequate to absorb the oxygen. Close stopcock M and remove the reductor. Invert the pipette several times to make the solution inside homogeneous, and then expel the gas column into the chamber as in Fig. III. Rotate the pipette at the same angle for one minute then invert it and withdraw the bubble. Record the length of the gas column and again expel the bubble into the bell, this time for 10 seconds. Repeat until a minimum reading is obtained.

If Stokes solution is the absorbent used it is not necessary to rinse out the sodium hydroxide as a preliminary. After CO_2 absorption bring the separatory funnel containing Stokes solution over stopcock N and fill the empty bell. Force the gas column into the bell for one minute as above (Fig. III), and repeat with 10-second additional exposures until a minimum reading is obtained. At the conclusion wash with water and 5 per cent acetic acid.

IV. Precautions.

Experiments are most frequently spoiled by air bubbles which remain in the bell and mix with the analytical sample. Before the top is attached they can be readily removed with a camel hair brush. When the apparatus is filled and the top on, the best procedure is to blow gently into the chamber above stopcock M until a large bubble collects in the bell. Close stopcock M and rotate the apparatus in such a manner as to roll the bubble over the whole inner surface where it will pick up any smaller bubbles. Fill the chamber above N and open M to let the large bubble out. Persistent trouble with bubbles suggests a greasy surface, for which the remedy is to wash with ether and leave overnight in contact with sulphuric-dichromate.

When the gas is brought into the capillary it is advisable to wait one minute for temperature equalization before reading the length of the column. The temperature of the water jacket is found to rise gradually during the first two or three tests of a series, due to the heat of the hand. Subsequently it shows little fluctuation.

If the temperature of the pipette varies by 1°C. or more during any one test it becomes necessary to apply a volume correction to the readings. This could be done by subtracting from each reading the vapor pressure of water at the appropriate temperature and reducing the dry gas volume to 0°C. Since the pressure does not change significantly during the test it could be assumed at a convenient value, e.g., 760 mm. Temperature corrections, however, are considerably simplified by reference to the accompanying table, which is based on the thermal coefficient of expansion of air. To use this table at the end of a test proceed as follows. From the highest temperature recorded for any reading subtract each of the lower temperatures. Look up in the table the number which corresponds to the length of each gas column and its temperature difference, and add this value to the length reading. After each reading except the highest is corrected in this way the calculations for percentage of oxygen, etc. may be made. For example:

	cm.	Difference in temp.	Value to be added	Corrected result
Initial length of column...	20.13 at 20°	5°	.37	20.50
After CO_2 absorption.....	19.01 at 22°	3°	.21	19.22
After O_2 absorption......	16.43 at 25°	..	...	16.43

$$CO_2 = (20.50 - 19.22) = 1.28 \text{ cm.} \qquad \frac{1.28}{20.50} = 6.24 \text{ per cent.}$$

$$O_2 = (19.22 - 16.43) = 2.79 \text{ cm.} \qquad \frac{2.79}{20.50} = 13.60 \text{ per cent.}$$

It may be noted that in this example neglect to apply a temperature correction would cause a decrease of 11 per cent in the carbon dioxide results, and 6 per cent for oxygen.

Grease the ground glass connection of the bell each time the top is to be put on so that there will be a clear film of lubricant without air bubbles. When stopcocks fail to turn with perfect ease they should be cleaned with ether and old grease removed from the capillaries with commercial pipe cleaners. A minimal amount of grease is then applied in a ring about each end of the stopcock, and worked in by turning the core in its casing. A well lubricated cock appears transparent throughout. In warm laboratories a vaseline-rubber-paraffin mixture such as "Lubriseal" of the Arthur H. Thomas Company, Philadelphia, makes the best lubricant.

Table for the correction of gas volumes. Explanation in text.

	Values to be added to correct for differences in temperature. Centimetres and degrees Centigrade.					
Length of gas column centimetres.	1°	2°	3°	4°	5°	6°
10	.04	.07	.11	.15	.18	.22
11	.04	.08	.12	.16	.20	.24
12	.04	.09	.13	.18	.22	.26
13	.05	.10	.14	.19	.24	.29
14	.05	.10	.15	.21	.26	.31
15	.06	.11	.17	.22	.28	.33
16	.06	.12	.18	.24	.29	.35
17	.06	.12	.19	.25	.31	.37
18	.07	.13	.20	.27	.33	.40
19	.07	.14	.21	.28	.35	.42
20	.07	.15	.22	.29	.37	.44
21	.08	.15	.23	.31	.39	.46
22	.08	.16	.24	.32	.40	.48
23	.08	.17	.25	.34	.42	.51
24	.09	.18	.26	.35	.44	.53
25	.09	.18	.27	.37	.46	.55

In the directions above it is advised that the gas column, after being exposed to an absorbent, withdrawn and read, be repeatedly exposed for as many 10-second periods as are necessary to obtain a constant reading. After several such exposures, however, the length of the column increases slightly and if this happens it will necessarily introduce errors. It is therefore best to keep the additional 10-second exposures as small in number as possible.

The whole procedure is based on the assumption that the capillary of the gas pipette is of uniform bore throughout, and it is well to test this with every pipette, by measuring the length occupied by a column in different graduated regions.

Sudden movements of the rubber tubing can stretch or shrink the column of gas sufficiently to introduce noticeable errors. In general the column tends to be a little longer when it is being pulled towards the rubber tubing than when it is being pushed toward the bell. For this reason it is unsafe to rely on a single reading. In a typical case duplicate readings of 22.45, 22.48, 22.46, 22.43 cm. were obtained for the length of the column, for which the probable error is ± 0.03 per cent.

RESULTS.

In a typical set of analyses of oxygen in atmospheric air the results were 20.88, 20.93, 20.33, 21.35, 20.55 per cent. The average is 20.81 ± 0.12; expressed as a percentage the probable error is ± 0.6. Krogh[2] reports that this last value can be reduced to ± 0.1 per cent, an accuracy which has only occasionally been attained in the present work.

Duplicate analyses on a sample of alveolar gas gave the following results:

	CO_2	O_2	N_2 etc. by subtraction
Individual Tests.............	7.16 6.15 5.76 5.65 6.22	12.57 14.10 14.21 13.23 13.47	80.27 79.75 80.03 81.12 80.31
Average.....................	6.19	13.52	80.29
Probable error ±.............	0.17	0.22	0.16
Percent P.E. ±..............	3	2	0.2

Comparing these values with those for inspired air it is seen that the nitrogen has increased from 79.02 to 80.29 per cent. Since the blood and tissues are already in equilibrium with the nitrogen of the air this gas is neither absorbed nor excreted in the lungs, consequently the amount of nitrogen which leaves with the expired air is the same as that which entered with the inspired air. The apparent increase is due to a reduction in the total gas volume during respiration. To compare the readings before and after respiration they must be referred to equivalent quantities of nitrogen, and to do this all the percentages of gas in the expired air are divided by 80.29 and multiplied by 79.02. The resultant figures are compared with those of inspired air in the following table.

	Nitrogen etc.	Oxygen	Carbon Dioxide
Inspired air (theoretical)	79.02	20.95	0.03
Expired air	79.02	13.31	6.09
Difference	.....	7.64	6.06

The respiratory quotient in this experiment is $\frac{6.06}{7.64} = 0.80.$

THE FISH POPULATION OF LAKE JESSE, NOVA SCOTIA.

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(Received May 9, 1938).

ABSTRACT.

This study is based on a sample of fish secured from Lake Jesse, Nova Scotia, following the treatment of the lake with copper sulphate (August 3, 1934) to eradicate predators and competitors of speckled trout. Practically all fish came into the shores. The fish production was estimated by counting and weighing fish from measured sections of the shore-line. The estimated population was 36,035 fish, or a production of 19.9 pounds per acre. The following species were present: *Salvelinus fontinalis*, *Notemigonus crysoleucas*, *Semotilus atromaculatus*, *Catostomus commersonnii*, *Ameiurus nebulosus*, *Anguilla rostrata*, *Fundulus diaphanus*, *Perca flavescens*, *Morone americana*, *Pungitius pungitius*. *Fundulus*, *Perca* and *Morone* were the most numerous species. Predator species, *Perca* and *Morone*, constituted 57 per cent of the population. Each species is discussed separately, and data on length, weight, sex and relative condition of the fish are presented. The growth rate of *Perca* and *Morone* was slower than that determined for other lakes. Females appeared to live longer, although both sexes grew at almost the same rate. The population was dominated by fish in the second, third and fourth years of age. There were few fish of the year, indicating the dominance of predators. Fish over four years of age were scarce. The dominance of certain year classes suggests a cycle in the fish production, which would determine a scarcity of fry in certain years and a scarcity of older fish in others. There are indications that some species may have migrated into and out of the lake. Fifteen thousand speckled trout fingerlings were introduced into the lake in each of the years 1929, 1931 and 1932; twenty-nine trout were secured in 1934. A fish population, predators and competitors, as found in Lake Jesse, appears inimical to successful planting with trout fingerlings.

This study is based upon a sample of fish obtained from Lake Jesse at the time that this lake was treated with copper sulphate (August 3, 1934). This treatment was for the purpose of eradicating the predators and competitors of speckled trout and was carried out under the auspices of the Fish Culture Branch of the Canadian Department of Fisheries. Accounts of the procedure are given in articles by Catt and Smith[1]. A preliminary note on the fish population of the lake has already been published[2].

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[1] Catt, *Trans. Amer. Fish. Soc.*, 64, 276-280 (1934); Smith, *Trans. Amer. Fish. Soc.*, 65, 101-113 (1935).

[2] Smith, *Trans. Amer. Fish. Soc.*, 65, 297-299 (1935).

CHARACTERISTICS OF LAKE JESSE.

Lake Jesse has an area of forty-five acres, a maximum depth of 6.6 metres, and an average depth of 2.4 metres (May 30, 1929) (Fig. I). The annual fluctuation of the water level is approximately 0.5 metre. The lake is situated on the head-waters of Salmon River, Yarmouth County, and has only one small inlet, which becomes dry in mid-summer, and an outlet which, after a run of about a mile, empties into Lake Annis, a much larger lake than Jesse. The bottom near shore is largely composed of rocks and rubble, while in the deeper water a soft ooze, containing much organic matter, predominates.

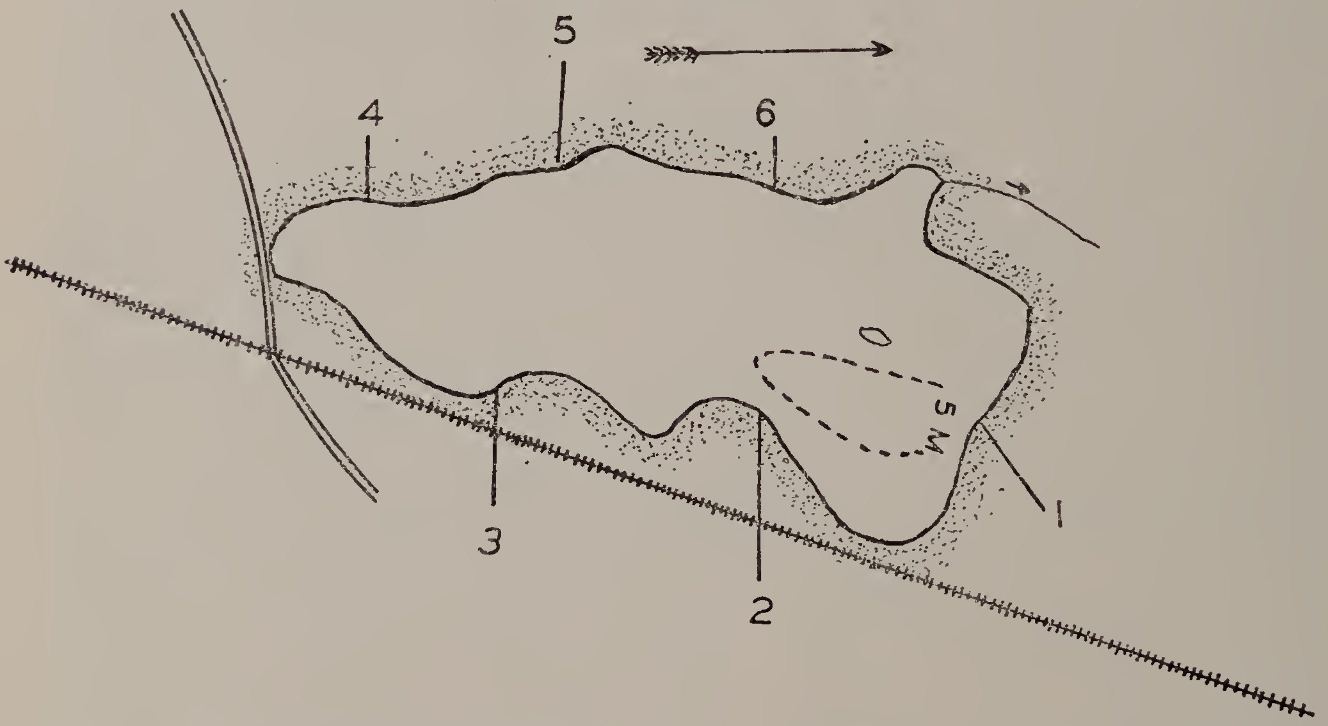

Fig. I. Sketch map of Lake Jesse. Areas over which fish were counted are indicated by numbers.

The waters do not become stratified during the summer months and are circulated thoroughly by any strong wind during that period. Thus the temperature and chemical conditions of the bottom and surface waters are usually quite similar. The waters are soft. On August 1, 1934, the pH values were 6.5 at the surface and 6.3 at a depth of 6.5 metres.

The phytoplankton is of the Caledonian type, with a dominance of desmids. The rooted emergent aquatic vegetation occupies only a small area, and at no place is it dense. The zooplankton, as taken in mid-summer, 1934, consisted principally of *Diaphanosoma brachyurum*, *Holopedium gibberum*, *Daphnia pulex*, *Diaptomus minutus* and *Mesocyclops obsoletus*.

The reader is referred to another publication[3] by the author for additional information upon the flora and fauna of the lake, as well as for more specific data upon the hydrological conditions.

METHODS.

Collection and enumeration of the fish.

Almost all the fish that were killed by the copper sulphate came either into the shallow water around the shores and died there, or were killed in the deeper water, came to the surface, and floated in. Actually a majority of the fish came into the shallow water when affected by the copper sulphate. With the aid of a water-glass, an examination of the bottom in deeper water (down to four metres) was made, and only a very few fish were noted away from the shore zone. No actual counts of the number of fish in the deeper water were made.

The presence of the fish in the shoal water at the shore made it possible to make an estimation of the total population by enumerating the number found on several areas scattered around the lake (Fig. I). The total shore-line was measured, and the areas upon which the fish were counted comprised one-eleventh of the total. For a sample all the fish from six smaller areas were preserved, with the exception of eels and bullheads, which were preserved from three such areas, as the means available for preservation of the fish were limited. All trout in the lake were enumerated as carefully as possible, since this species was of special interest. Twenty-four trout were measured as to length and then discarded.

Measurements.

The sample was preserved in ten per cent formalin from five to six months before measurements were taken. A discussion of the changes of weight and length upon preservation will be given below.

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[3] Smith, *Proc. N. S. Inst. Sci.*, 19, 253-263 (1938).

Length.—Lengths were taken to the nearest millimetre and represent the distance from the snout to the shortest rays of the caudal fin (knotch of the tail). This length is used throughout the paper unless otherwise indicated. In the case of the killifish (*Fundulus*), with a truncate tail, this length is the total length. This also applies to the eel. For conversion to the standard length, where required, the following factors were used, and were based upon measurements of fish covering the entire length range of the sample. No regular change in the value of the factors was noted over this range. The species and factors are:

Notemigonus crysoleucas (golden shiner)	0.874	($\text{S.E.}_m = \pm 0.0007$)
Perca flavescens (yellow perch)	0.878	($\text{S.E.}_m = \pm 0.0008$)
Morone americana (white perch)	0.867	($\text{S.E.}_m = \pm 0.0012$)

Weight.—The fish were weighed to the nearest half-gram on a torsion balance. In the case of the yellow perch fry, however, the weight was taken to the nearest quarter-gram. The killifish were weighed in groups of one length frequency. All other fish were weighed individually.

Age determination.

Age determinations by examination of scales were made for the yellow and white perch. The scales were mounted and examined under a binocular or projection apparatus. The scales were taken from the region lying below the spinous dorsal fin, above the lateral line in the case of the white perch and below in that of the yellow perch. No trouble was experienced in making the determinations for fish up to four or five years of age, but for scales from a few older specimens in the sample a precise reading was difficult.

An examination of scales from the golden shiner was also made, but these could not be satisfactorily read. Precision was also difficult with the few speckled trout scales that were secured from fish taken in Lake Jesse.

Treatment of the data.

The standard error of the averages was calculated from the formula: $\text{S.E.}_m = \dfrac{\sqrt{\dfrac{\Sigma\, \delta^2}{N}}}{\sqrt{N}}$.

Length-weight curves of the general form, $W = c\, L^n$, have been constructed by the method of least squares. Group averages were used in the calculations and not individual measurements.

The "condition factor" K was determined from the equation, $K = \dfrac{10^2 \times W}{L^3}$. Length (L) is considered in centimetres and weight (W) in grams.

The reader is referred to Hile[4] for a discussion of the "cube law", $W = cL^3$, and of the general equation, $W = c\, L^n$, in their relations to fisheries work.

STANDING CROP OF FISH.

The estimated crop.

From the sample of fish obtained from Lake Jesse at the time of the copper sulphate poisoning, an estimation of the total standing crop of fish has been made. The results of this estimation are presented in Table 1.

Semotilus, *Catostomus* and *Pungitius* were represented in the lake by small numbers, and did not occur on those areas from which the sample was taken, although one or two individuals of each were found on the total area counted over. *Perca flavescens* was the dominant species numerically, making up a little over forty per cent of the total population. However, *Ameiurus nebulosus* and *Morone americana*, although they comprised a smaller percentage of the population, gave, due to their larger average size, a greater production in pounds per acre, namely 5.1 and 5.5 pounds per acre respectively, as against 4.6 for *Perca*. *Fundulus diaphanus* was plentiful and constituted almost twenty-nine per cent

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[4] Hile, *Bull. U. S. Bur. Fish.*, 48, 211-317 (1936).

TABLE 1.

Standing Crop of Fish in Lake Jesse.

Species	Number	Per cent of total	Number in sample	Total weight		Number per acre	Pounds per acre
				Grams	Pounds		
Salvelinus fontinalis	29	0.08	5	7,911	17.4	1	0.4
Notemigonus crysoleucas	2,611	7.45	111	41,227	90.9	58	2.0
Semotilus atromaculatus	22	0.06	.....	....	.....	...	....
Catostomus commersonnii	22	0.06	.....	....	.....	...	....
Ameiurus nebulosus	1,179	3.37	21	104,342	230.0	26	5.1
Anguilla rostrata	1,095	3.13	29	13,362	29.5	24	0.7
Fundulus diaphanus	10,098	28.83	325	31,910	70.3	224	1.6
Perca flavescens	14,177	40.48	497	93,006	205.0	315	4.6
Morone americana	5,781	16.51	229	113,308	249.9	128	5.5
Pungitius pungitius	11	0.03	.....	....	.....	...	....
Totals	35,025	.....	1,224	405,066	893.0	776	19.9

of the total. Their weight averaged about three grams per fish, thus giving the comparatively small production of 1.6 pounds per acre. *Salvelinus fontinalis*, the most desirable species from the viewpoint of the angler, was scarce; twenty-nine specimens were found in the entire lake, and these represented less than one per cent of the population.

Reliability of the estimation.

The reliability of this estimation depends primarily upon the effectiveness of the copper sulphate in killing the fish and upon how well the distribution upon the areas over which the counts were made represented that on the remaining shore-line. Change of weight upon preservation in formalin might also introduce an appreciable error.

It has been concluded that the number of fish that survived the copper sulphate treatment, with the possible exception of the eel, was small. That a certain number did survive, for one cause or another, is shown by the following observations previously recorded (Smith[2], p. 110):

> "On August 5, two days after the copper sulphate had been added, a school of about twenty-five killifish were noted at the outlet from Lake Jesse, and two yellow perch and a few eels along the shore. By use of a large seine two small yellow perch were captured on August 6 in a number of hauls at various points about the lake. Catt[1] also observed killifish on August 9 at the outlet and captured one white perch in a twenty fathom gill-net. On October 3 one killifish was seen. Set-lines (25 hooks), baited with fish and earthworms, captured two eels on May 10, 1935. The same lines continued from May 16 to 21 inclusive yielded no fish. A gill-net set during the entire period of the May investigations caught nothing.
>
> Our observations indicated that a number of eels survived, for on the morning of August 4, there appeared to be a larger number of these fish alive in the shallow water at the immediate shore-line than later found dead. We anticipated that all would eventually die, so no actual count was made; thus, unfortunately we have no figures to subtantiate our observation."

The various species of fish were by no means equally distributed in the lake. Thus, for example, the greatest number of *Notemigonus* and *Morone* were found at the north end of the lake, adjacent to the deepest water. On August 3, 1934, the day on which the lake was treated with copper sulphate, there was a steady wind blowing from the south-east, and on August 4, a light wind from the south-west. Floating fish would therefore drift toward the north end. Actually it was found, presumably owing to the proximity to the deep water and to the wind direction, that a greater number of fish were on the northern shores than elsewhere about the lake. There are no data to indicate how well the larger number found there was balanced by the smaller number at the southern end. Collection of the entire population was desirable but at the time not feasible. Although the areas counted over were kept under observation for a week comparatively few fish were found after the second day. There appeared to be no drift of fish from one area to another once the fish had become stranded in the shallow water, or washed upon the shore.

Hile[4] found a shrinkage factor for weight of 1.181 and 1.144 for ciscoes from two Wisconsin lakes. These fish were first preserved in ten per cent formalin and then in seventy per cent alcohol, and were held for about five weeks. He did not use the factors however to correct individual weights as he found the variation per fish fluctuated widely. Shrinkage factors for length have also been determined for certain species of fish preserved in formalin and alcohol [4-5].

To obtain additional information upon the change in weight we preserved specimens of several species of fish in ten per cent formalin. After a period averaging about 270 days, it was found that most of the fish gained rather than lost weight. The ratio, volume of body cavity to total body volume, appeared to be correlated with the changes observed, the larger this ratio the greater the gain in weight. Thus perciform species (*Micropterus*, *Perca*, *Morone*) showed the most gain, while pickerel (*Esox*) increased less in weight, and the eel (*Anguilla*) and killifish (*Fundulus*) lost weight. The abdomens of these fish were not incised. Neither were those

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[5] **Van Oosten,** *Bull. U. S. Bur. Fish.*, 44, 265-428 (1929); Shetter, *Copeia*, 1936, no. 1, pp. 60-61 (1936).

in the Lake Jesse sample, since most of the specimens were small. Incising white perch (average weight about fifty grams) made a difference, although there was still considerable gain in weight. Thus, the factor, preserved weight to fresh weight, for incised perch was 1.075 and for unincised, 1.127. This factor for unincised killifish was 0.969, determined from a sample of sixty-eight fish.

If we consider the shrinkage in weight of killifish as being representative of that experienced by those in the Lake Jesse sample, we find that the total poundage of this fish as given in Table 1 should be increased from 70.3 to 72.5, which makes little difference in the poundage per acre (0.05 pounds). If we do the same for the white perch (unincised), although only a few of the larger specimens from Lake Jesse were comparable in size to those designated above, the total estimated poundage should be reduced from 249.9 to 221.7, which lowers the poundage per acre by 0.6. More data are required in order to apply general corrections in this paper, however, for it was found that there was considerable fluctuation in the individual loss or gain of weight, as for instance in the case of the pickerel, which showed individual changes from a loss of 0.04 to a gain of 0.6 per cent.

Production in other freshwaters.

The estimated standing crop of fish for Lake Jesse falls between the crops (17.0 and 36.0 pounds per acre) estimated for Boar's Back and Tedford Lakes, two other lakes which are situated in the same region of Nova Scotia and which were also treated with copper sulphate[6]. It is somewhat smaller than the standing crop (29.0 pounds per acre) estimated by Eschmeyer[7] for a small Michigan lake, which was treated with derris root, and considerably greater than that (8.4 pounds per acre) found by M'Gonigle and Smith[8] in McCormick Lake, Nova Scotia, which was also treated with derris root. Since not all the fish were recovered, Eschmeyer considers that the standing crop for the Michigan Lake probably exceeded thirty pounds per acre. Whereas the populations of Jesse, Boar's Back and Tedford Lakes comprised several species of fish, that in the Michigan Lake was entirely yellow perch, except for a small number of introduced trout, and in McCormick Lake, entirely of speckled trout. The data for the lakes referred to are presented in Table 2.

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[6] Smith, *Trans. Amer. Fish. Soc.*, 67, (In press).
[7] Eschmeyer, *Pap. Mich. Acad. Sci. Art. Let.*, 22, 613-628 (1937).
[8] M'Gonigle and Smith, *Prog. Fish Culturist*, *U. S. Bur. Fish.*, *Mem.* 1-131, no. 38, 5-11 (1938).

TABLE 2.

Standing Crops of Fish in Certain Lakes.

Lake and Authority	Acreage	Number of species	Number per acre	Pounds per acre
Boar's Back (Smith).............	55.8	7	498	17.0
Tedford (Smith)..................	52.0	7	1658	36.0
South Twin (Eschmeyer).........	4.3	1	955	29.0
McCormick (M'Gonigle and Smith)	6.0	1	102	8.4
Jesse...........................	45.0	10	776	19.9

Records of the standing crops of fish in streams show in many cases a higher production than herein recorded for lakes. In Second River, Nova Scotia, M'Gonigle and Smith[8] found that the standing crop of salmon parr and speckled trout in several sections of the stream varied from 0.7 to 573.8 pounds per acre, with an average for all sections of 112.4 pounds. From counts made on one-hundred foot sections of New York streams Greeley[9] gives estimations of the standing crops varying from 16.7 to 247.6 pounds of fish per acre. Trippensee[10] presents records for fish populations in a number of New Hampshire streams. They are based on sections of the streams that were seined, and Trippensee considers that the efficiency of the sampling varied from seventy to ninety-three per cent in numbers of fish. He gives the production for streams of the Saco drainage as varying from zero to 85.89 pounds per acre. In ten cases, that he presents, the estimation varied from 1.03 to 6.66 pounds per acre, in five others from 11.55 to 17.22, and in an additional three, 29.47, 51.84 and 85.89 pounds per acre. For southern streams, Viosca[11] estimates that the total standing crop in spring-fed brooks of southern Louisiana is between 300 and 500 pounds per acre.

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[9] Greeley, State of N. Y., *Conserv. Dep., Biol. Survey* (1933), no. 8, pp. 53-108 (1934); Idem, *Biol. Survey* (1934), no. 9, pp. 63-101 (1935); Idem, *Biol. Survey* (1935), no. 10, pp. 45-88 (1936).

[10] Trippensee, *N. H. Fish and Game Dep., Survey Rep.*, no. 2, pp. 119-124 (1937).

These data are for uncultivated waters. In rearing ponds where the fish are fed, or in fertilized carp, tench or eel ponds the production may exceed a ton of fish per acre [11-12].

Discussion on the Species of Fish.

Salvelinus fontinalis (Mitchill)—Speckled trout.

Twenty-nine speckled trout were secured from Lake Jesse after a careful search for this species had been made. The angling history of Lake Jesse indicates that in times past good catches of trout were made, but with more intensive fishing these diminished and in recent years were poor, although these waters were stocked with 15,000 number one trout fingerlings in each of the years 1929, 1931 and 1932[13]. It was of special interest, therefore, to determine the trout population as an indication of the survivals from these plantings, particularly since it was known that in late years Lake Jesse supported numbers of yellow and white perch.

One specimen of the twenty-nine trout, with a length of 40.0 cm. and a weight of 821.0 gm., was decidedly larger than the rest. The other twenty-eight individuals varied in length from 19.0 to 27.2 cm., with a mean length of 23.7 cm. ($S.E._m = 0.45$). An examination of the scales from four specimens (lengths: 20.6, 21.5, 24.1 and 24.4 cm.) placed their ages in the third year. The small number of fish involved in the age determinations made a precise reading difficult and subject to error, since there was little material from the lake for comparative purposes. We feel justified in concluding, however, that the twenty-eight fish were in their third or fourth years of age, and thus presumably represent the survivals in Lake Jesse of the 1931 and 1932 plantings.

[11] Viosca, *Trans. Amer. Fish. Soc.*, 65, 350-358 (1935).

[12] Langlois, *Prog. Fish Culturist, U. S. Bur. Fish., Mem.* 1-131, no. 7, pp. 1-7 (1935).

[13] Rodd, *Annual report on fish culture for* 1929, Dep. Fish. Can., pp. 1-78 (1931)
Annual report on fish culture for 1931, Idem, pp. 1-67 (1932);
Annual report on fish culture for 1932, Idem, pp. 1-72 (1934).

For speckled trout from streams in the Allegany State Park, New York, Kendall and Dence[14] found that sixteen fish in their third year, collected in August, 1922, had an average total length of 155.25 mm., and that nine more of the same age collected in the summer of 1921 had an average total length of 135.2 mm. Ricker[15] determined for three Ontario habitats, a cold Chara pond, a warm hard-water river, and a Laurentian Lake, that in their third year speckled trout attained an average total length of 19.05 cm., and in their fourth year an average of 26.7 cm. If we consider the trout from Lake Jesse as being in their third year, comparisons in regard to lengths show that the growth of trout from this lake was greater than that made by the fish in the Allegany streams, but was of the same order as determined by Ricker for Ontario waters.

Four individuals from Lake Jesse had an average length of 22.65 cm. and an average weight of 135.75 gm. Based on this small sample, we have calculated that the "condition factor" K has a value of 1.17. For the largest specimen (40.0 cm.) the value of K equals 1.28. Ricker[15] has calculated a "condition number" based on the length-cubed relationship: $\text{"condition number"} = \frac{\text{weight in pounds} \times 10^5}{(\text{length in inches})^3}$. Length was measured to the fork of the caudal fin as in the author's cases. Converting to a gram-centimetre relationship we secure the "condition factor" K used in this paper. Thus for trout from five Ontario habitats the value of K varies from 1.19 to 1.48.

Of the five preserved specimens from Lake Jesse, two were females and three males.

Notemigonus crysoleucas crysoleucas Mitchill—Golden shiner.

The golden shiner made up 7.5 per cent of the estimated population, and gave a poundage per acre of 2.0, ten per cent of the total.

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[14] Kendall and Dence, *N. Y. State College of Forestry, Roosevelt Wild Life Bull.*, 4, 289-482 (1927).

[15] Ricker, *Univ. Toronto Stud., Biol. Ser., Publ. Ont. Fish. Res. Lab.*, no. 36, pp. 69-110 (1932).

There were 111 specimens in the sample. The length frequencies of these fish are shown in Figure VII, from which it may be seen that the total range was from 6.2 to 13.9 cm. The average length for the entire group was 10.4 cm. ($\text{S.E.}_m = 0.16$).

The individual preserved weight varied from 3.0 to 36.0 gm., with a mean for the sample of 15.8 gm. ($\text{S.E.}_m = 0.69$). The length-weight relationship of the fish is presented in Figure II, where the curve expressing the relationship has been

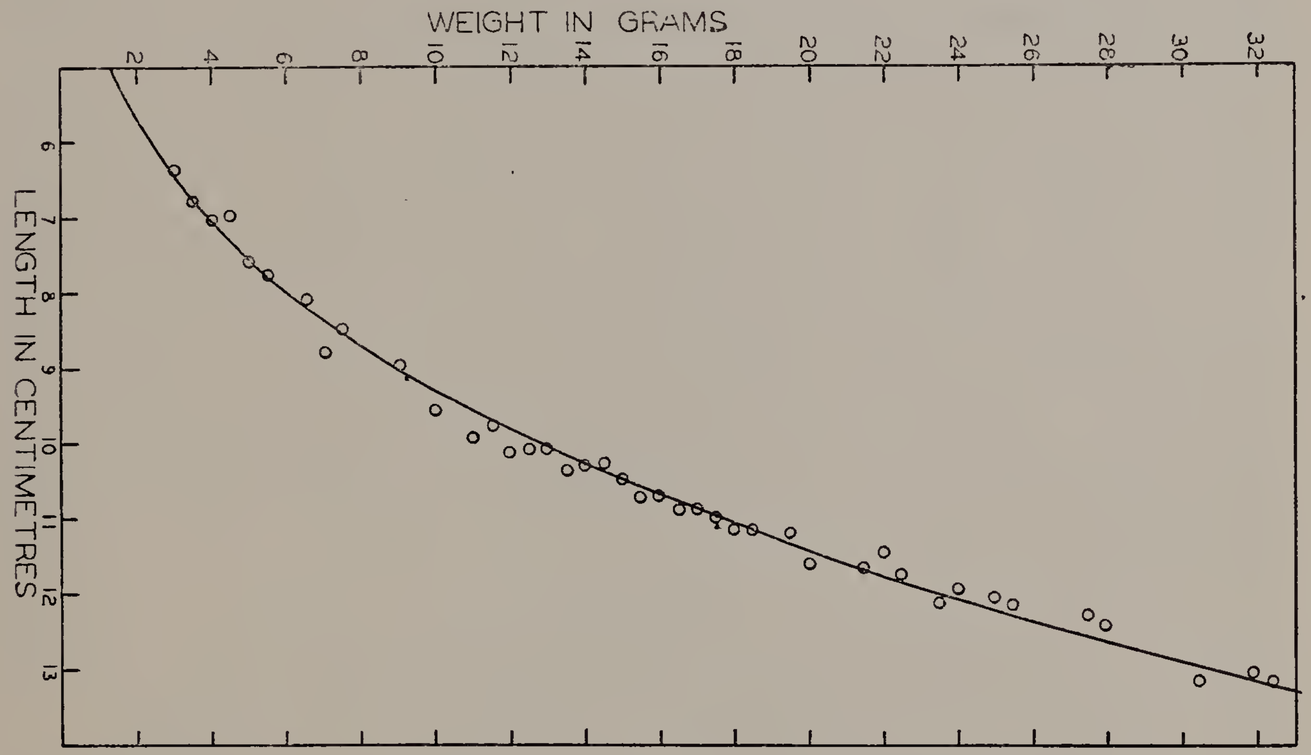

Fig. II. Length-weight relationships of *Notemigonus crysoleucas*.

calculated as $W = 0.006146L^{3.31}$. From the curve it can be shown that, within the length range of the sample, the increase in weight per unit length is quite large, particularly in the older fish. Thus between 7.0 and 8.0 cm the increase was 2.9 gm., while between 11.0 and 12.0 cm. it was 5.75 gm., or twice the rate for the smaller fish.

The "condition factor" K was determined for each five-gram interval of the weight. The determinations are set forth in Table 3. The values of K provide a measure of the relative condition or heaviness of the various groups of fish, for as Hile[4] (p. 239) states "—values of K, by reason of their calculation from the cube relationship, are direct and quantitative measures of form or relative heaviness, and in this sense are directly comparable between fishes of any length." The value of K, however, would appear to be affected by certain factors. Ricker[15] found that for large trout heavy feeding considerably increased the value of the constant, as well as the approach of the spawning season in the females, but not in the males. Clark[16], in the case of *Sardina*, and Schneberger[17], in the case of the yellow perch, concluded that undigested food had no appreciable effect. These latter fish would be of the same order of size as the golden shiners from Lake Jesse. The youngest golden shiners from Lake Jesse were not mature, while the greater proportion of the older females were spent, although some were still gravid. The average value of K for five gravid females, averaging 11.0 cm. in length, was 1.32 as compared to a value of 1.28, the average for the weight group to which they belonged. With the Lake Jesse shiners, the variation is apparently not very large, and so males and females, immature and mature, are lumped together in the calculations for the results shown in Table 3.

TABLE 3.

Values of K for Notemigonus Crysoleucas.

Weight in grams	Number of fish	Average value of K
3.0– 7.5	18	1.17
8.0–12.5	15	1.18
13.0–17.5	41	1.28
18.0–22.5	19	1.35
23.0–27.5	6	1.43
28.0–32.5	8	1.36
33.0–37.5	1	1.34

The data show that the value of K increases as the fish become older, except for the last two groups which comprise a small number of specimens. This increase perhaps shows that Lake Jesse was as suitable, if not a better habitat for the larger fish as for the small. *Notemigonus* feeds upon a variety of invertebrate forms, both of the plankton and of the bottom fauna, and in some cases algae[18]. The data appear to indicate that the species is an efficient converter of basic fish foods.

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[16] Clark, *Div. Fish and Game California, Fish. Bull.*, no. 12, pp. 1-59 (1928).
[17] Schneberger, *Trans. Wis. Acad. Sci. Art. Let.*, 29, 103-130 (1935).

Scales from the Lake Jesse specimens were mounted and examined but they could not be satisfactorily read. Cooper[19] was able to determine the age by scale reading of the subspecies *auratus* from Michigan and of the typical form from New York. From a comparison between the standard lengths of the Lake Jesse fish on the one hand and of the Michigan and New York fish on the other, we would conclude that only a few of the fish from Lake Jesse were five years old, and that the dominate group of the population was three years of age.

The sex was not determined in the smallest fish (5.6 to 6.9 cm. standard length). Of the remainder in the sample, forty-four were males and forty-nine females, a ratio of 1:1.11. If this sample is divided into two groups at 10.0 cm. of length (standard), the ratio of males to females is 1: 0.68 under this length, but 1: 3.83 over it. In fact all fish over 10.5 cm. were females. Cooper[19] also found for *auratus* that females predominated among the older fish, in other words lived longer.

Notemigonus is usually considered a late spring and summer spawner. Thus Wright and Allen[20] give the spawning period for New York waters as May to July 1. Hubbs and Cooper[21] state that they have observed spawning in Michigan from June into August, with indications that in some waters it may begin in May. In Lake Jesse, 26.5 per cent of the females were considered gravid, i.e quite a number had not spawned by August 3. These individuals occurred over the entire length range of the mature fish. Below the 10.0 cm. length nineteen per cent of the females were gravid, while above this size thirty-five per cent were considered ready to spawn. The absence of golden shiner fry in Lake Jesse at the time the waters were poisoned is explained by the fact that the treatment was carried out in the midst of of the shiners' spawning period.

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[18] Ewers, *Trans. Amer. Fish. Soc.*, 63, 379-390 (1933); Forbes and Richardson. *Nat. Hist. Surv.* Ill., 3, 1-357 (1909); Moore, *U. S. Bur. Fish., App. Rep*, 1922, pp. 1-60 (1922).

[19] Cooper, *Pap. Mich. Acad. Sci. Art. Let.*, 21, 587-597 (1936).

[20] Wright and Allen, "*The fauna of Ithaca, N. Y.: Fishes.*" Zool. Field Notebook, Ithaca, pp. 4-6 (1913).

[21] Hubbs and Cooper, *Bull. Cranbrook Inst. Sci.*, no. 8, pp. 1-95 (1936).

As shown by the distribution of the dead fish along the shores, following the copper sulphate treatment, the golden shiners were largely confined to the deepest water at the north end of the lake and in a region free from aquatic vegetation. As a rule this species prefers shallow waters which contain an abundance of aquatic plants. Adams and Hankinson[22] found the majority of this fish in this type of habitat in Oneida Lake, New York, although they did take larger individuals in more open waters without vegetation. Hankinson[23] indicates that, in Michigan lakes, *Notemigonus* occurs most plentifully in the vegetal shallows, with a secondary preference for the *Potamogeton* zone. Their occurrence in the open water is not listed.

Semotilus atromaculatus (Mitchill)—Horned dace or creek chub.

Two specimens of this species were secured from Lake Jesse, measuring in length 8.7 and 17.0 cm.

Semotilus is typically a fish of brooks and streams. Evermann, according to Adams and Hankinson[22], indicates that the species may be found in larger creeks and rivers, and more rarely in lakes and ponds. It is apparently distributed throughout New Brunswick and Nova Scotia, and was recorded in 1852 by Perley[24a] under the name *Leuciscus cephalus* as being common in rivers and streams of the two provinces. The writer has taken the species in the Tusket river system (Sullivan's flowage), Nova Scotia.

Catostomus commersonnii (Lacépède)—Common or white sucker.

A few fairly large suckers were found in Lake Jesse. Three specimens were preserved and these had lengths of

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[22] Adams and Hankinson, *N. Y. State College of Forestry, Roosevelt Wild Life Ann.*, 1, 235-548 (1928).
[23] Hankinson, *Pap. Mich. Acad. Sci. Art. Let.*, 17, 553-574 (1932).
[24] Pearse, *Bull. U. S. Bur. Fish.*, 35, 249-292 (1918).
[24a] Perley, "*Reports on the sea and river fisheries of New Brunswick.*" 2nd. ed., Fredericton, pp. 1-228 (1852).

35.8, 47.0 and 51.0 cm. The smallest of these (35.8 cm.) weighed 684.0 gm.

The only suckers present in Lake Jesse were mature fish. This indicates that either all the fry of this species that might have been in the lake fell prey to other fish, or that these larger individuals represented a few strays from the waters below. Lake Jesse is a head-water lake with no tributaries, except the outlet, in which suckers might spawn. Actually the outlet presents few gravel beds and other areas suitable for spawning. Thus, it is concluded that the absence of small suckers in Lake Jesse was due to a lack of spawning facilities, and that those present were strays which had penetrated into Lake Jesse from Lake Annis, while seeking spawning grounds in the outlet. Conversations with fishermen familiar with Lake Annis revealed that suckers are plentiful there.

Ameiurus nebulosus (LeSueur)—Bullhead or Horned pout.

The estimated number of *Ameiurus* in Lake Jesse constituted 3.4 per cent of the total population, but, due to the comparatively heavy individual weight, the poundage per acre, 5.1, was second largest for the lake. This poundage was 25.6 per cent of the total.

Twenty-one specimens made up the sample for this species. The length range of the sample was from 8.1 to 23.7 cm., the mean of which was 18.4 cm. ($S.E._m = 0.67$). The average weight was 89.7 gm. ($S.E._m = 7.89$). One specimen was decidedly smaller than the rest. It measured 8.1 cm. in length and had a weight of 7.0 gm. If we exclude this individual, the remainder were grouped fairly close together in size around a mean length of 19.9 cm. ($S.E._m = 0.46$).

Data for the length-weight relationship have been plotted in Figure III. The curve expressing this relationship is $W = 0.009109\ L^{3.125}$.

Anguilla rostrata LeSueur—Eel.

The eels killed in Lake Jesse were, as a whole, small. In the sample one specimen measured 75.0 cm. in length

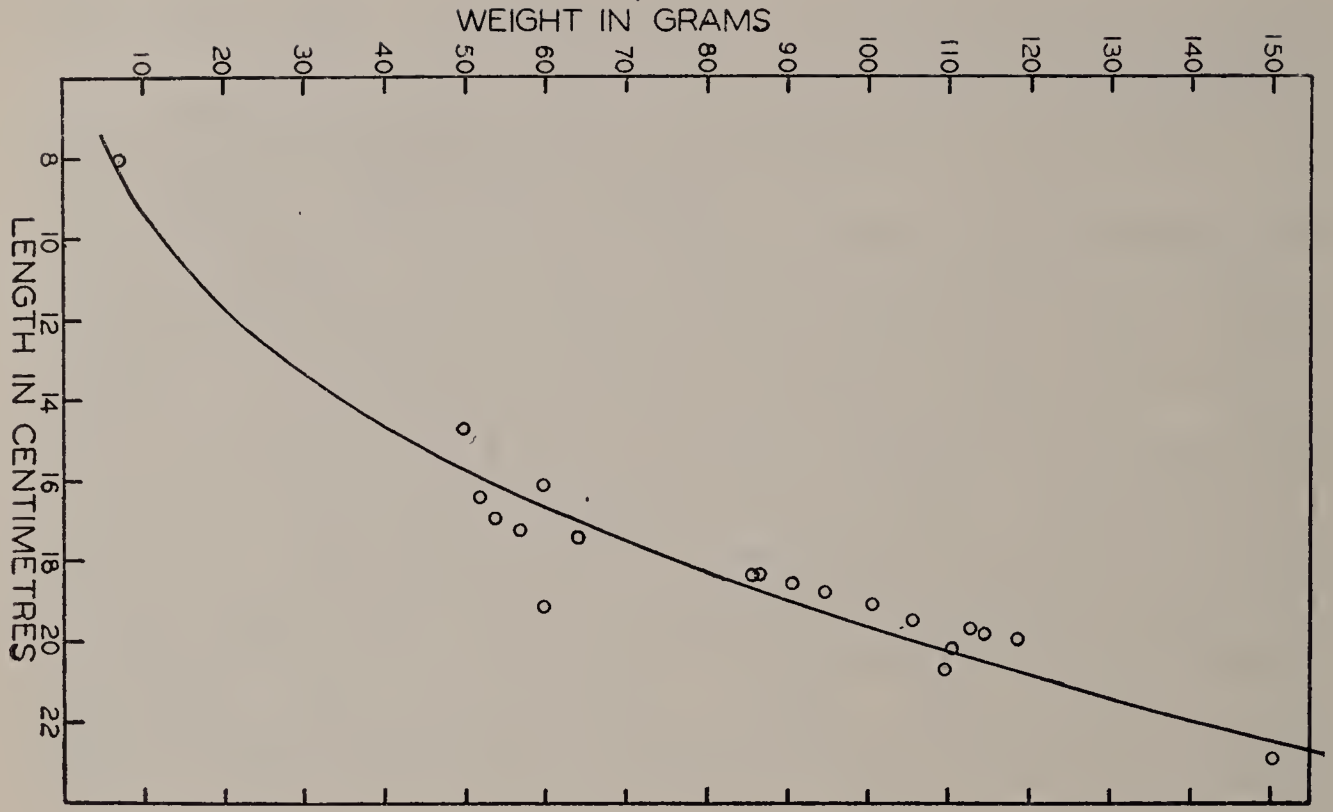

Fig. III. Length-weight relationships of *Ameiurus nebulosus.*

and weighed 840.0 gm. The remainder, however, had a much smaller average length of 19.4 cm. (S.E.$_m$ =3.7), and an average weight of 12.75 gm.

In such species of fish as *Notemigonus*, *Perca* and *Morone*, the "condition factor" K $\left\{\frac{10^2 \text{ W}}{\text{L}^3}\right\}$ usually has a value greater than one, indicating that the weight is increasing out of proportion to the cube of the length. When we calculate the K values for the eel we find the reverse relation, namely that the cube of the length is increasing out of proportion to the weight. Thus the average K value for the eels from Lake Jesse was 0.161. For the single large specimen in the sample it was 0.198, and for the remainder 0.157 (average). The values of K for the Lake Jesse eels are compared in Table 4 with values for eels from two other lakes of the same region of Nova Scotia. As a whole the values are smaller for Lake Jesse, showing a less robust condition of the eels from this lake.

TABLE 4.

Values of K for Eels from Three Nova Scotian Lakes.

Lake	Number of fish	Length range, cm.	Range of K values	Average value of K
Boar's Back........	12	17.2–26.5	0.142–0.217	0.176
Tedford............	19	9.1–24.9	0.134–0.227	0.173
	89	25.0–51.0	0.173–0.246	0.207
Jesse...............	28	18.7–23.4	0.144–0.175	0.157
	1	75.0	0.198	0.198

As noted above, most of the eels from Lake Jesse were small. We have indicated before that a certain number of eels apparently survived the copper sulphate treatment. There is, however, no evidence at hand that the poison was selective in its action, killing a greater proportion of the smaller than of the larger individuals.

The eel is a catadromous species. As the fish become older and approach maturity, they migrate to lower waters on their way to spawn in salt water. Lake Jesse, as with the other lakes indicated in Table 4, is a head-water lake. The comparative absence of larger eels in these lakes could be explained by postulating that during the last few years of their life in fresh-water the eels gradually drop down from the head-waters into deeper basins nearer the sea. The three lakes in question do in fact have deeper and larger lakes lying immediately below them.

Fundulus diaphanus (LeSueur)—Killifish.

Killifish constituted almost twenty-nine per cent of the fish population in Lake Jesse. It is a small species, however, and, with its average weight of 3.2 gm., gave 1.6 pounds per acre, only a little over eight per cent of the total poundage for the lake. There were 325 specimens in the sample.

The length frequencies for the fish in the sample are presented in Figure VII. No satisfactory results were secured from attempts to determine the age of this species from the scales, but it is apparent that the population was very poorly represented by fish of the year, which condition likely reflects the predator action of the dominant perch. Further, the length frequencies define a group, with an average length of about 5.5 cm., which is considered to consist of fish one plus years of age. Above a length of 6.1 cm., the length frequencies are bunched together. Without corroboration it is impossible to say whether we are dealing with a group predominately two plus years of age, and a few older fish, or with two groups, one of two plus and the other of three plus years, and a few older fish.

The entire length range of the sample was from 2.5 to 9.2 cm. The average length was 6.9 cm. ($S.E._m = 0.06$). Adams and Hankinson[22] give a maximum length of 11.4 cm. (4.5 in.) for specimens of the subspecies *menona* collected by them in Oneida Lake, New York. The length-weight relationship is shown in Figure IV. The curve expressing this relationship has been calculated as $W = 0.005411\ L^{3.25}$.

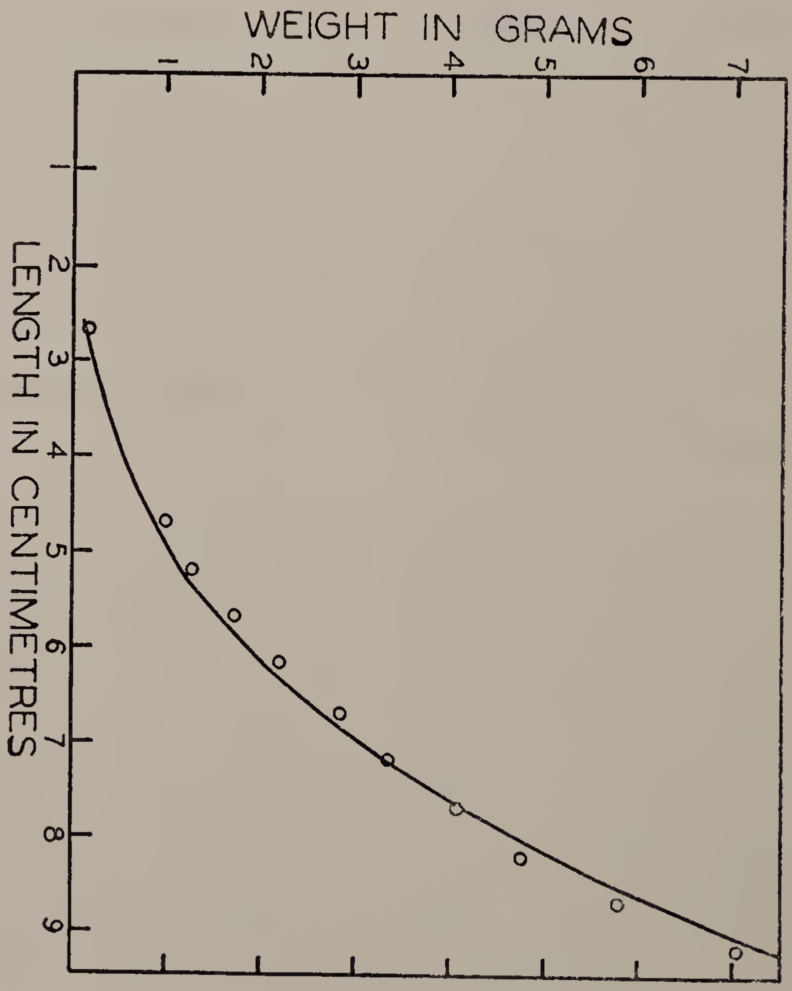

Fig. IV. Length-weight relationships of *Fundulus diaphanus.*

The values of K, based on the total lengths, for the Lake Jesse killifish have been determined for each five millimetres of length (Table 5). Leaving out of consideration the two fish of the year, and by taking moving averages for the K values, it is shown that the K values, as a whole, decrease as the fish become older, or in other words the fish appear to lose condition or comparative heaviness. The food of killifish comprises a wide selection of organisms, but entomostracans and insect larvae constitute a large proportion of their diet[24]. Such foods were not scarce in Lake Jesse. No evidence seems available to explain the trend of the K values.

TABLE 5.

Values of K for Fundulus Diaphanus from Lake Jesse.

Length, cm.	Number of fish	Value of K	Moving average
2.5–2.9	2	0.635	.....
4.5–4.9	14	0.934	.....
5.0–5.4	26	0.889	0.910
5.5–5.9	26	0.907	0.902
6.0–6.4	23	0.911	0.917
6.5–6.9	63	0.934	0.909
7.0–7.4	53	0.881	0.900
7.5–7.9	61	0.885	0.873
8.0–8.4	40	0.854	0.871
8.5–8.9	14	0.873	0.875
9.0–9.4	3	0.899	.....

Perca flavescens (Mitchill)—Yellow perch.

The yellow perch is common to abundant in many freshwaters of the Maritimes. In Lake Jesse it was numerically the dominant species, comprising a little over forty per cent of the estimated population. The poundage per acre was estimated at 4.6, or 24.2 per cent of the total. In poundage per acre, however, the yellow perch was surpassed by the less abundant, but individually heavier, bullheads and white perch. There were 497 yellow perch in the sample.

The length frequencies for the yellow perch in the sample are presented in Figure VII. In this figure there is shown a well defined group of frequencies around an average length of 3.6 cm. segregated from the others. This group represents the fish of the year, as might be judged from viewing the figure, and as determined from scale readings. These fish made up 8.5 per cent of the population of yellow perch. From age determinations by scale readings the two groupings of frequencies around 7.6 and 9.2 cm. are shown to represent fish one plus and two plus years of age. These two year classes dominated the perch population, particularly that of one plus years of age, which comprised 63.9 per cent of the total. There were few fish three plus and four plus years of age. Four fish, still older, are not indicated in Figure VII. No precise determination of their ages was made, although they are considered to be in their eighth or ninth years. These fish had lengths of 16.3, 16.7, 18.0 and 20.3 cm.

Average lengths and weights for the yellow perch in the sample from Lake Jesse are given in Table 6. These data are presented for each year of age, up to four plus years, and by sexes, except for fish of the year, in which cases the males and females are not separated. The average lengths (standard) and increments of length for each year of age for the Lake Jesse perch are compared in Table 7 with similar data obtained from a number of lakes by other investigators.

TABLE 6.

Average Lengths and Weights for Perca Flavescens from Lake Jesse.

Age in years	Sex	Number of fish	Average length, cm.	S.E.m	Average weight, gm.	S.E.m
0+	?	42	3.6	0.059	0.5	0.053
1+	♀	140	7.8	0.038	5.5	0.074
1+	♂	176	7.7	0.042	5.4	0.075
2+	♀	74	9.3	0.060	8.3	0.174
2+	♂	34	9.1	0.063	8.15	0.166
3+	♀	19	10.8	0.135	13.8	0.135
3+	♂	2	10.8	.....	13.75	.....
4+	♀	1	12.8	.....	23.0	.....
4+	♂	2	12.4	.....	21.5	.....

TABLE 7.

Comparison of Lengths and Increments in Length by Age of Perca Flavescens from Several Habitats. Standard Length.

I. Length in millimetres.

Lake and Authority	Age					
	0+	1+	2+	3+	4+	5+
Erie (Jobes[25])	69	150	178	197	316	250
Nebish (Schneberger[17])	56	124	157	173	209	245
Erie (Harkness[27])	44	...	144	168	187	217
Wawasee (Hile[26])	39	86	129	167	198	220
Weber (Schneberger[17])	53	95	130	158	174	191
Silver (Schneberger[17])	45	77	109	120	145	173
Winona (Bolen[28])	..	79	111	137	175	...
South Twin (Eschmeyer[7])	..	87	86	118	129	...
Jesse	32	68	81	95	111	...

II. Increments of length in millimetres.

Lake and Authority	0+	1+	2+	3+	4+	5+
Erie (Jobes)	69	81	28	19	19	34
Nebish (Schneberger)	56	68	33	16	36	34
Erie (Harkness)	44	..	..	24	19	30
Wawasee (Hile)	39	47	43	38	31	22
Weber (Schneberger)	53	42	45	28	16	17
Silver (Schneberger)	45	32	32	11	25	28
Winona (Bolen)	..	..	32	26	38	..
South Twin (Eschmeyer)	..	..	1 (-)	32	11	..
Jesse	32	36	13	14	16	..

In general, the perch from Lake Jesse were decidedly smaller for their age than determined for the fish from the other lakes indicated in the tables. The data for the Lake Jesse perch most closely agree with those from South Twin Lake[7]. In Lake Jesse, the fish were killed on August 3, 1934, and in South Twin Lake on September 20, 1934. Thus it may be assumed that the Lake Jesse perch, if they had been allowed to grow until the latter date, would have more nearly approached in size those from South Twin Lake. The fish in the other lakes were taken from spring until fall.

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[25] Jobes, *Pap. Mich. Acad. Sci. Art. Let.*, 17, 643-652 (1933).

[26] Hile, "*Investigations of Indiana Lakes*," no. 2, Publ. no. 107, Dep. Consrve Ind., pp. 7-55 (1931).

[27] Harkness, *Univ. Toronto Stud., Biol. Ser., Publ. Ont. Fish. Res. Lab.*, no. 20, pp. 87-95 (1922).

[28] Bolen, *Proc. Ind. Acad. Sci.*, 33, 307-309 (1923).

As shown by the data in the second part of Table 7, the perch in Lake Jesse grew most rapidly in length during the first two years of life. In the third year there was a sharp drop in this increase in length, which, however, was then maintained almost on the same level during the fourth and fifth years. This sharp drop in length growth is in agreement with the findings of Jobes[25] for perch from Lake Erie, and also of Schneberger[17] for perch from Nebish Lake, Wisconsin. Jobes indicates that this radical change in growth may be associated with the attainment of sexual maturity in the fish. Yet, in other lakes there may be no manifestation of this sudden decrease in length growth in the third year. According to Hile's[26] data, for instance, the growth rate of perch in Wawasee Lake, Indiana, is gradual in its decline, or comparatively so, as the fish became older. It would appear that the attainment of sexual maturity does not always cause a sudden decline in the increase of length, although it may remain a potential factor. Good growing conditions at the time the fish reach sexual maturity might overshadow possible adverse effects of this physiological change. Examination of the ovaries of the Lake Jesse perch indicated that the fish spawned during the spring that they reached two complete years of age. Aside from the sudden drop in length growth in the third year, it was found for the Lake Jesse perch that there was also a drop in the weight increment (Table 6), which thereafter increased, and, further, a drop in the value of the factor K for the third year (Table 8). These observations appear to substantiate Jobes' postulation.

Average values for the factor K are given in Table 8, for the various ages and for both sexes, when determined. In Table 9 we have compared the values of K for the Lake Jesse perch with those determined by Hile[26] for Wawasee Lake, Indiana, by Schneberger[17] for Nebish, Weber and Silver Lakes, Wisconsin, and by Eschmeyer[7] for South Twin Lake, Michigan. Much of these data are the same as used by Eschmeyer[7] (Table VI, p. 623).

TABLE 8.
Values of K for Perca Flavescens from Lake Jesse.
(Standard Lengths used.)

Age in years	Sex	Number of fish	Average values of K by years and sex	Average values of K by years
0+	♀ and ♂	42	1.62	1.62
1+	♀	140	1.70	
1+	♂	176	1.72	1.71
2+	♀	74	1.61	
2+	♂	34	1.61	1.61
3+	♀	19	1.61	
3+	♂	2	1.61	1.61
4+	♀	1	1.62	
4+	♂	2	1.66	1.64

TABLE 9.
Comparison of Values of K for Perca Flavescens from Several Lakes.

Lake and Authority	Age				
	0+	1+	2+	3+	4+
South Twin (Eschmeyer)....	....	1.49	1.49	1.43	1.42
Wawasee (Hile)............	....	1.51	1.63	1.60	1.77
Nebish (Schneberger).......	....	1.67	1.64	1.63	1.72
Weber (Schneberger)........	....	1.65	1.44	1.54	1.61
Silver (Schneberger)........	....	....	1.57	1.60	1.61
Jesse (Smith)..............	1.62	1.71	1.61	1.61	1.64

The perch in Lake Jesse apparently found the conditions more suitable for their well-being in the second year than at any other time of their life. This is indicated by the higher value for K of 1.71 than for the other fish, for which the value of K averaged 1.62. On the whole, the values of K for the Lake Jesse perch are of the same order as found by Hile and Schneberger, but greater than those determined by Eschmeyer for the perch from South Twin Lake.

In the latter case, Eschmeyer considers that the fish in South Twin Lake represented a population of stunted perch. He bases his contention upon the small size of the fish for their age and on the lower values of K as compared to perch from other lakes. The perch in Lake Jesse grew slower but had higher K values, i.e. were relatively stouter fish, than those from South Twin Lake. This seemingly presents an anomalous situation, which, however, might be explained on the following basis. If a lake has a higher temperature and a poorer food supply than another lake, then the fish in the first lake will grow faster, but will be of a poorer condition, than those in the second lake, with its cooler temperatures and relatively better food supply. In other words, in the first lake the food supply is not adequate to meet the physiological requirements of the fish, while in the second these demands are fulfilled. Actually South Twin is a smaller lake than Jesse (4.3 acres as compared to 45 acres), and thus

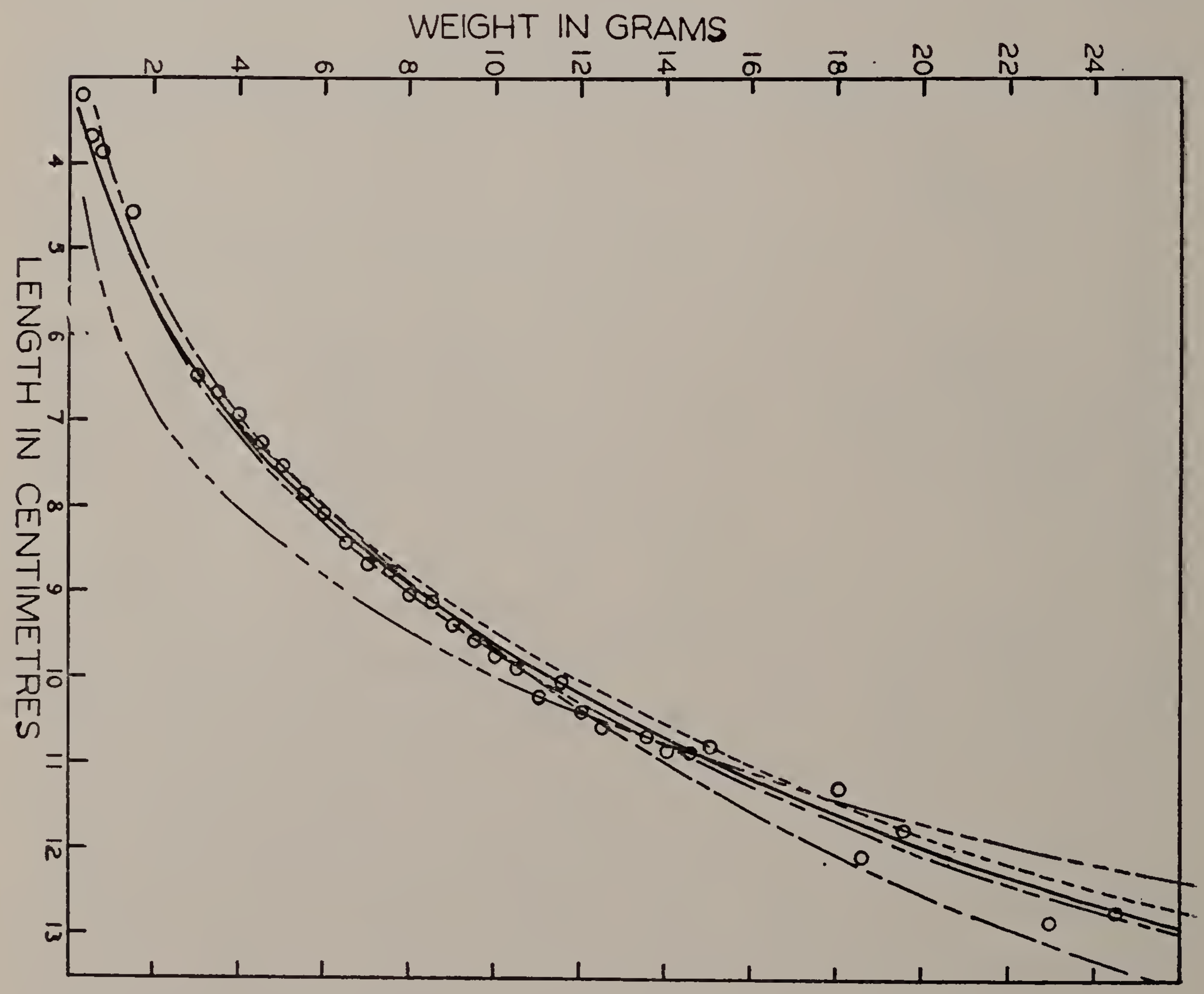

Fig. V. Length-weight relationships of *Perca flavescens.*
- - - - - - - one plus years, females;
—— - —— one plus years, males;
—— - - - —— two plus years, males;
—— - - - - —— three plus years, females;
———————— all fish, males and females.

might be expected to be warmer over a longer season. Further, Eschmeyer considers that there was a scarcity of food organisms for perch of intermediate size in South Twin Lake.

On the other hand, although the growth rate of perch in Lake Jesse was low when compared to the lakes investigated by Hile and Schneberger, the values of K were quite similar. For three Wisconsin lakes, Schneberger concludes that the rate of growth was in inverse proportion to the relative abundance of fish. Hile states that the food conditions in Lake Wawasee, Indiana, were excellent. Since all these lakes in question may have comparable water temperatures, at least less difference in this regard between these lakes and Jesse than between Jesse and South Twin, it may be possible to ascribe the low growth rate of the perch in Lake Jesse to a *relatively* poor food supply or a *relative* abundance of fish.

Expressions of the length-weight relationships by the function $W = CL^n$ for perch of various ages and both sexes, as well as for the population as a whole, are plotted in Figure V. Constants for this function for the perch are tabulated in Table 10. The equation expressing the length-weight relationship of female fish two plus years of age ($W = 0.008405\ L^{3.12}$) is not shown in Figure V since over the range of the curve that would be illustrated in the figure, it coincides with the equation for the entire population ($W = 0.009596\ L^{3.07}$).

For the perch population it is seen that the value of the exponent of the length (n) varies considerably in value, not

TABLE 10.

Constants of the Function $W = CL^n$ for Perca Flavescens from Lake Jesse. W = Weight in Grams. L = Length to the Shortest Rays of the Caudal Fin.

Age	Sex	Value of C	Value of n
1+	♀	0.009632	3.08
1+	♂	0.002039	2.72
2+	♀	0.008405	3.12
2+	♂	0.007297	3.17
3+	♀	0.0004581	4.34
All ages	♀ and ♂	0.009596	3.07

only from one year class to another, but also within one year class when the sex is differentiated. As illustrative of the difference in the value of the constants, consider the perch one plus years of age. For the females the value of *n* is 3.08, while that for the males is considerably lower at 2.72. Hile[4], dealing with the cisco, has also remarked that the values of *n* are not constant for a species or a population. He says in part (p. 246): "—the values of *n* determined for a single year's sample apply only to the length intervals for which the equations are fitted and do not hold for fish whose lengths lie outside these length ranges."

Sex was not determined for fish of the year, but was for all older fish. An analysis of the sex ratio, considering the perch population by years and as a whole, is given in Table 11. Considering the population as a whole, insofar as the sex was determined, females were somewhat more numerous than males, the actual proportions being 52.7 per cent females and 47.3 per cent males. For the perch one plus years of age, males were more plentiful. In this year class, 55.7 per cent were males. In the older fish, females began to predominate, and in the case of the fish two plus years of age the females constituted 68.5 per cent, and of the three plus, 86.4 per cent.

TABLE 11.

Sex Ratios for Perca Flavescens from Lake Jesse.

Age	Sex	Number of fish	Per cent by years of age	Per cent of the total
0+	?	42	.....	8.5
1+	♀	140	44.3	28.3
1+	♂	176	55.7	35.6
2+	♀	74	68.5	15.0
2+	♂	34	31.5	6.9
3+	♀	19	86.4	3.8
3+	♂	2	13.6	0.4
4+	♀	1	33.3	0.1
4+	♂	2	66.7	0.4
Older fish	♀	4	100.0	0.8
All ages except fish of the year	♀	238	52.7	....
	♂	214	47.3	....

Eschmeyer[7] found for the South Twin Lake, Michigan, that for the entire perch population the sex ratio was 74 females per 100 males, a ratio very close to that ascertained for the Lake Jesse perch one plus years of age. Eschmeyer indicates, as we have found for Lake Jesse, that the males are more abundant among the younger fish. Schneberger[17], for Wisconsin Lakes, found a ratio of females to males of 1:1.26 in Nebish Lake, but in Weber and Silver Lakes, ratios of males to females were 1:1.31 and 1:1.40 respectively. As pointed out by Eschmeyer, Schneberger was dealing with netted fish, and thus had comparatively few young fish in his samples. If he had had a larger number of young fish possibly males would have made up a greater proportion of the population. He did find that males were more plentiful among the younger fish.

Eschmeyer interprets his data as indicating that females live longer than males. The data for the Lake Jesse yellow perch seem to corroborate this view. Although there appeared to be a difference in the length of life between the two sexes, yet male and female perch grew at practically the same rate in Lake Jesse.

Morone americana Gmelin—White perch.

The general distribution of this species, according to Bigelow and Welsh[29], is along the Atlantic coast from the Gulf of St. Lawrence and Nova Scotia to South Carolina. These authorities say (p. 258): "Apparently it does not occur at all in salt water in the Bay of Fundy." The white perch is reported to breed either in brackish or fresh water. In the more northern part of its range, the species occurs in many lakes, and these populations, at least in part, are considered to be land-locked.

There were 229 specimens of white perch in the sample from Lake Jesse. There it made up 16.5 per cent of the fish population by number and 27.6 per cent by weight. This species and the yellow perch constituted the greater part of the predator fish population in Lake Jesse.

Bigelow and Welsh, *Bull. U. S. Bur. Fish.*, 40, 1-567 (1924).

The length frequencies found in the sample, as illustrated in Figure VII, show quite definite groupings, which coincide closely with the various year classes. The dominant year classes were composed of fish in their second, third and fourth years of age. Thus fish in their second year constituted 32.7 per cent of the white perch population, in their third year, 35.4 per cent, and in their fourth year, 21.4 per cent. Two perch, not indicated in Figure VII, were either in their ninth or tenth year of age, and measured 27.2 and 29.9 cm. in length.

A peculiarity of the white perch population in Lake Jesse was the absence of fish of the year. In the case of the other dominant species, killifish and yellow perch, specimens of fish of the year were secured, although they were relatively scarce. White perch fry, however, appeared to be completely absent. Certain possibilities might account for the phenomenon. First, any spawning in Lake Jesse in 1934 may have been a complete failure. Spawning takes place in southern New England in April, May and June[29], and in the Chesapeake Bay region in April and May, and possibly during the winter[30]. Cameron[31] secured white perch fry from Wheaton's Lake, New Brunswick, on July 17, 1929. These fish ranged in length (standard) from 1.5 to 2.1 cm. Thus, it would seem probable that any surviving fry from a 1934 spawning in Lake Jesse would have been noted, particularly since a search was made for them. The second possibility is that no spawning by white perch took place in Lake Jesse and that the population of this species was represented by immigrants into the lake. Although the sample has not yet been fully analysed, the same situation apparently obtained in neighbouring Tedford Lake, which was also treated with copper sulphate. There is not sufficient evidence, however, to give a more precise explanation of this peculiarity.

Considering the white perch sample from Lake Jesse as a whole, the average length was 11.2 cm. ($S.E._m = 0.16$). The average length of the fish by year classes and sex and the average weight by year classes are given in Table 12.

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[30] Hildebrand and Schroeder, *Bull. U. S. Bur. Fish.*, 43, 1-366 (1927).
[31] Cameron, *Biol. Bd. Can., Mss. Rep. Biol. Sta.*, no. 61 (1929).

TABLE 12.

Lengths and Weights of Morone Americana from Lake Jesse.

Age	Sex	Number of fish	Average length, cm.	S.E.$_m$	Average weight, gm., by years	S.E.$_m$
1+	♀	39	9.2	0.056	....	.....
1+	♂	36	9.1	0.081	9.1	0.128
2+	♀	48	11.1	0.042	....	.....
2+	♂	33	10.9	0.063	17.2	0.139
3+	♀	26	12.8	0.117	....	.....
3+	♂	23	12.55	0.117	25.1	0.361
4+	♀	7	13.9	2.15	....	.....
4+	♂	8	13.65	1.83	32.7	0.257
5+	♀	4	15.6	.....	....	.....
5+	♂	3	15.4	.....	47.1	.....

Concerning the rate of growth of this species, Hildebrand and Schroeder[30], writing in 1928, say (p. 246): "Virtually nothing is known of the rate of growth of the white perch." They indicate that fish taken in April, ranging in length from 7.4 to 14.0 cm., may have been one year old. Another sample of white perch, length range from 5.5 to 6.5 cm., taken in the lower Rappahannock River on July 25, is considered by them to consist of fish of the year. Cameron[31] presents data on length and age for white perch secured on June 25, July 17 and August 7 from Wheaton's Lake, New Brunswick. She obtained no fish in their second year of age, which may have been a result of the method of netting the samples. For white perch in their third, fourth and fifth years, the average standard lengths, male and female grouped together, were 12.25, 14.01 and 16.04 cm. respectively. For the Lake Jesse white perch the corresponding standard lengths were 9.6, 11.0 and 11.9 cm. Thus, comparing the two perch populations, it is seen that the fish from Lake Jesse grew at a decidedly lower rate. This is in agreement with the growth characteristics of the yellow perch from Lake Jesse when compared to most other habitats examined.

Length-weight relationships for the white perch in the sample are shown in Figure VI. Curves have been developed for this relationship for each year of age, males and females

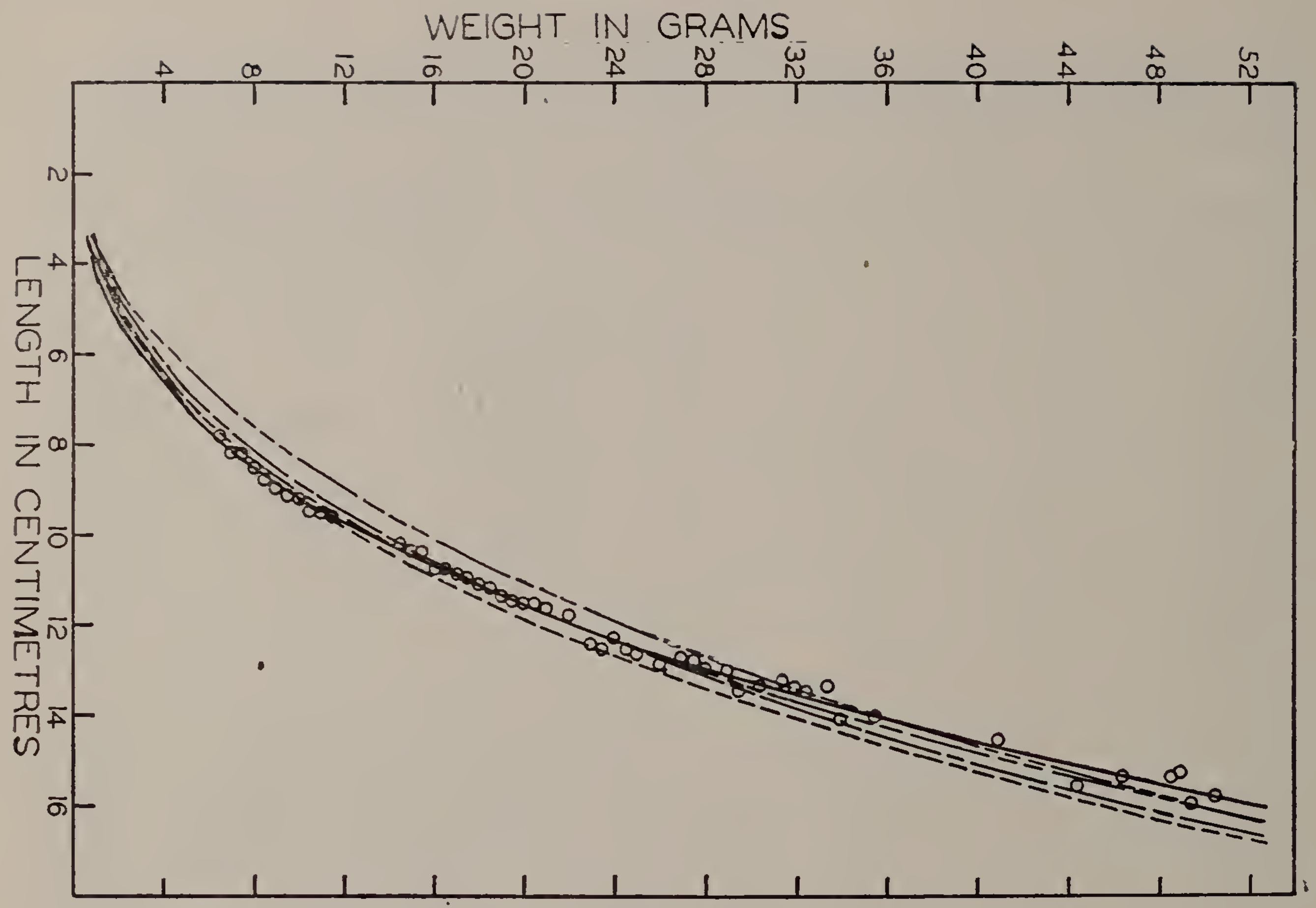

Fig. VI. Length-weight relationships of *Morone americana.*
– – – – – – – one plus years;
—— – —— two plus years;
—— – – – —— three plus years;
——– – – – —— four plus years;
———————— all fish.

grouped together, as well as for the entire sample. The curve for the perch over four plus years of age ($W = 0.01367\ L^{2.98}$) coincided so closely with that for the entire sample ($W = 0.01247\ L^{3.02}$) over the range shown in Figure VI that it could

TABLE 13.

Constants of the Function $W = CL^n$ for Morone Americana from Lake Jesse. W = Weight in Grams. L = Length in Centimetres to the Shortest Rays of the Caudal Fin.

Age	Value of C	Value of n
1+	0.02003	2.79
2+	0.03229	2.63
3+	0.02109	2.80
4+	0.05333	2.47
Older fish	0.01367	2.98
All ages	0.01247	3.02

not be illustrated. The constants for the function expressing the length-weight relationships are presented in Table 13.

It may be seen, as was also the case with the yellow perch, that the value of the exponent of length (n) varies in value from year class to year class. The use of this type of curve, based on fish in one year class or on a restricted group of fish, for the purpose of extrapolating lengths and weights from those portions of the curves lying outside the range of data to which the curves were fitted, may lead to considerable error. Further, the use of the constant C, determined empirically from the function, $W = CL^n$, rather than from the cube relationship, $W = CL^3$, as a coefficient of the condition of the fish gives an erratic and erroneous result. This has already been pointed out by Hile[4].

The "condition factor" K for the various ages of white perch from Lake Jesse showed little variation. Thus the average values of K (males and females together) for the fish in their second year was 1.22, in their third year, 1.29, in their fourth year, 1.23, and in their fifth year, 1.24. No other data seem available for comparison in this regard.

Cameron[31] found that a small sample of white perch taken on June 25 in Wheaton's Lake consisted of 66.7 per

TABLE 14.
Sex Ratios for Morone Americana from Lake Jesse.

Age	Sex	Number of fish	Per cent by years of age	Per cent of total
1+	♀	39	52.0	17.0
1+	♂	36	48.0	15.7
2+	♀	48	59.3	21.0
2+	♂	33	40.7	14.4
3+	♀	26	53.0	11.4
3+	♂	23	47.0	10.0
4+	♀	7	46.7	3.1
4+	♂	8	53.3	3.5
5+	♀	4	57.1	1.7
5+	♂	3	42.9	1.3
Older fish	♀	2	100.0	0.9
All ages	♀	126	55.0	....
	♂	103	45.0	....

cent females. Larger samples taken on July 17 and August 7 gave the percentages of females as 65.4 and 51.2. For the entire sample from Lake Jesse, 55.0 per cent were females. Table 14 outlines the distribution of sex by year classes. Females were somewhat in excess for the year classes most plentifully represented in the lake, i.e. one plus, two plus and three plus. Unlike the yellow perch from Lake Jesse, female white perch were more abundant than males in their second year of age. There is some indication, however, that female white perch live longer than males, since the two older fish indicated above were females.

Pungitius pungitius (Linnaeus)—Nine-spined Stickleback.

Only one specimen of this stickleback, which is common in many fresh-waters of New Brunswick and Nova Scotia, was secured from Lake Jesse.

Discussion.

Size of fish.

The fish population in Lake Jesse was dominated by fish in their second, third and fourth years. In the case of the yellow perch it was fish one plus and two plus years of age, while with the white perch these two year classes, along with fish three plus years, were fairly equally represented. With the killifish it was also these classes that were most plentiful. Thus, considering the population as a whole, there was a scarcity of fish of the year, and also a scarcity of older fish, of four or more years of age.

In the population as it existed in 1934, although the yellow and white perch were potential predators of the killifish, for instance, little predator action was apparently possible, since, in general, the size of all the most abundant species was quite similar (Fig. VII). The abundance of these predators in the lake would, however, explain the failure of the 1934 class of fish, due to the predator action of the dominant year classes against spawn and fry. Golden shiner fry were not taken since the fish were killed at the time of spawning. The absence of white perch fry might require a further explanation, as noted above.

The scarcity of older fish is not so easily explained. In the case of the killifish it seems possible that the fish complete a normal life span in the lake. Jordan[32] gives the usual maximum size of this species as four inches, and the largest specimens taken by Adams and Hankinson[22] in Oneida Lake were 4.5 inches in length. The largest individuals taken in Lake Jesse measured 3.6 inches (9.2 cm.). The yellow perch definitely reach larger sizes than was found for the general run of this species in Lake Jesse, and fish over four years of age may constitute a good proportion of yellow perch populations[17,25,27]. With white perch it is also known that the species

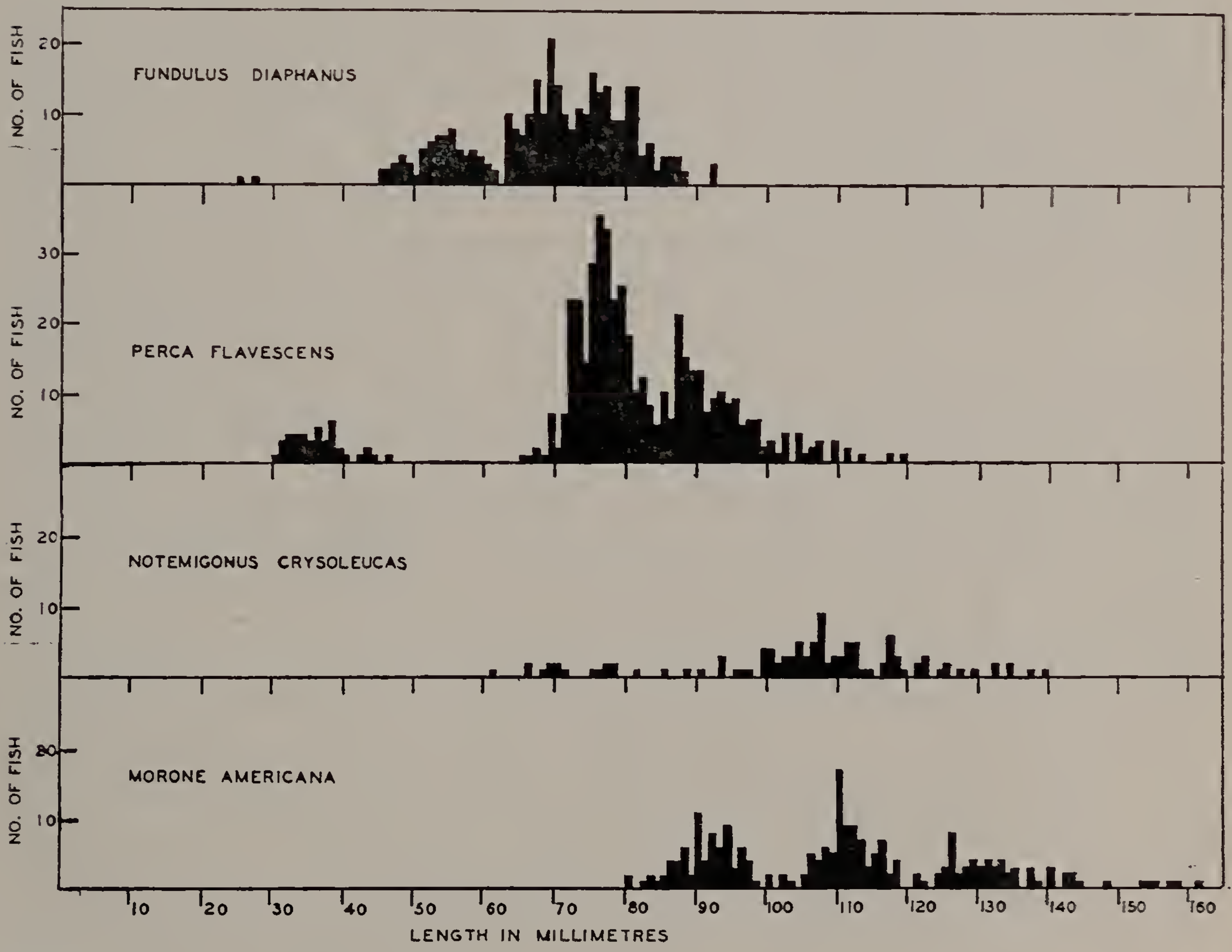

Fig. VII. Length frequencies for *Fundulus*, *Perca*, *Notemigonus* and *Morone*.

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[32] Jordan, "*Manual of the vertebrate animals of the northeastern United States*," New York, pp. 1-446 (1929).

grows to a much larger size than encountered in Lake Jesse, although most of the records are for fish from brackish or salt water[29,30]. We are aware that larger specimens of white perch are found in Lake Annis, which receives the drainage from Lake Jesse, but there is no information upon the abundance of these larger fish. The golden shiner may likewise attain larger sizes than found in Lake Jesse, although Hubbs[33] states that in small bodies of water the shiner may remain dwarfed. Thus, in summary, it seems indicated that for some species the scarcity of old fish may be attributed to a completion of the life span at a small size. Other species, as yellow and white perch, might be expected to grow larger. Food cannot be ascribed as the factor determining the size attained by these fish in Lake Jesse, for there was no apparent paucity of invertebrate fish foods in the lake, and there were plenty of fish, one and two years of age, to serve as a source of food for larger predator species. Schneberger[17], for Wisconsin yellow perch, has postulated that slow growing fish live a longer span of life than fast growers. Lake Jesse perch, as compared to those from the Wisconsin Lakes, were definitely slow growers, and from this viewpoint we might have expected a larger number of older fish than was actually observed.

There may be the possibility that the older fish in certain cases had migrated from Lake Jesse into the deeper and larger Lake Annis and waters below. We have already suggested that the suckers found in Lake Jesse were immigrants in the reverse direction. We have also postulated that the scarcity of large eels in Lake Jesse was due to migration downstream in connection with the seaward spawning run, although taking place sometime before the fish were mature. Further, if it was the case that the white perch in Lake Jesse were immigrants from elsewhere, it is logical to expect that spawning fish would migrate from the lake.

Cycle in the fish production.

The dominance of certain year classes suggests a cycle in the fish production of Lake Jesse. It is apparent that fry, of most species present in the lake, produced in 1931, 1932 and 1933 were able to survive in good numbers. Since there were comparatively few large predator fish to prey upon these year classes, it might be assumed that they would have continued to dominate the fish population in Lake Jesse until a large percentage of them had completed their normal life span in the lake, i.e. either died or migrated. The 1934 year class of the entire population was a near failure. The cause for this may largely be attributed to the predator action of the 1931, 1932 and 1933 year classes of both yellow and white perch. If the fish population had been unmolested, probably the year class of 1935 would also have been a failure, and this would have continued in successive years, with diminishing intensity, until the classes of 1931, 1932 and 1933 had largely disappeared.

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[33] Hubbs, *Trans. Ill. State Acad. Sci.*, 11, 147-151 (1921).

We have suggested above that the scarcity of fish four years of age and older was due to migration from the lake. A cycle in the fish production would also provide an explanation. The existence of dominant year classes during the few years before 1931 would determine a scarcity of fish four, five, and six years of age, and perhaps older, in 1934. By 1931 these fish would have become less plentiful, and thus would permit the year classes of 1931, 1932 and 1933 to build up, which in their turn would check the population in 1934. The presence of a few yellow and white perch about eight years of age in Lake Jesse in 1934 may well indicate the remnants of a dominating population prior to 1931.

We cannot say how long the 1931, 1932 and 1933 year classes would have continued to dominate the fish population in Lake Jesse, and thus no definite period to the suggested cycle can be given.

Eschmeyer[7] states that presumably a cycle of three years occurred in the yellow perch of South Twin Lake. He believes that in this lake the fish largely died of starvation in their third year. Huntsman[34] points out a cycle, averaging 9.6 years, in the scarcity of Atlantic salmon in the waters of the Maritime

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[34] Huntsman, *Trans. Roy. Soc. Can.*, 3rd. Ser., 31 (sec. V), 17-27 (1937).

Provinces of Canada. He considers the scarcity is determined during the fresh-water stage of the salmon's life. He says (p. 26): "It develops that low water could be a factor causing scarcity through making the large parr, on which kingfishers and mergansers feed, easily available to these birds." Thus, during the dry summers the fry and small parr, due to the removal of the larger competing parr, would survive in greater numbers, and the year classes that these small fish represent would be favoured.

Fish culture implications.

Under the discussion on the brook trout we indicated that Lake Jesse had been stocked with 15,000 fingerlings of this species in each of three years, 1929, 1931 and 1932. Only twenty-nine trout were secured when the lake was treated with copper sulphate in 1934. The survival from these plantings was very low. It is generally considered that perch populations are inimical to success in planting trout fingerlings. The perch population as it existed in Lake Jesse in 1934 is considered to have destroyed a very large proportion of the fry of almost all species, and if plantings of trout fingerlings had been made in that year, it is natural to expect that the survival would have been poor. However, in 1931 and 1932, when the plantings were made, the situation was different. Since the fry of several species were quite successful in those years, it is probable that larger predator perch were scarce, and that introduced trout fingerlings would have encountered not so much predator action as competition for food and space from a large number of small fish of different species, of which fish of the year would constitute a good proportion. If the fish cycle, as postulated above, operated in Lake Jesse, then the planting of trout in 1929 did, on the other hand, encounter a perch population consisting in large part of older individuals, and the poor survival of trout could be ascribed to the predator activities of these perch.

During the years in question angling was poor in Lake Jesse. In fact, it was the scarcity of trout in this lake, following the plantings already indicated, that prompted the treatment of the lake with copper sulphate in order to rid it of the undesirable species.

These observations would seem, therefore, to warrant the conclusions that not only are plantings with trout fingerlings unsuccessful in waters maintaining fish of sufficient size to prey upon the fingerlings, but also in waters, where predator action is comparatively slight, but competition by small fish heavy. This perhaps explains the lack of success in stocking waters with trout fingerlings which do not appear to contain trout predators, but there does exist direct competition for food, etc., on the part of other small species.

ACKNOWLEDGMENTS.

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TEMPERATURE CHARACTERISTICS FOR CERTAIN FRESH WATERS.

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ABSTRACT.

Bodies of water can be readily compared insofar as temperature is concerned, and the suitability of any body of water for various aquicultural purposes can be readily determined by fitting the "sine curve" to temperature observations. Ponderous masses of temperature readings, otherwise difficult to handle, are reduced and made easy of treatment (liquidated). A measure of that very important ecological factor, temperature, is hereby provided.

> "The considerable effect of relatively small changes of temperature on the biological processes of marine plants and animals has been discussed, and it is apparent that the temperature of the water is a factor of primary importance in its effect on the population."—H. W. Harvey.[1]

I.

The importance of knowledge of the temperatures and heat content (calories) of bodies of water is recognized universally, but it is of greatest interest, probably, to meteorologists and biologists. Welch[2] states that "since the heat content of a lake is a matter of vital importance in limnology, methods of determining *heat budgets* are necessary". He discusses the methods developed by Birge[3] and states that such heat budgets "form an important method of comparing lakes with respect to heat content".

Hachey[4] developed a method of comparing water and air temperatures, by means of fitting a sine curve to accumulated temperature data. The purpose of the present paper is to demonstrate the value of this latter method, as a measure or means of comparing habitats insofar as the important ecological factor, temperature, is concerned.

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[1] Harvey, H. W., "*Biological Chemistry and Physics of Sea Water*", Cambridge. 1928, p. 133.

[2] Welch, P. S., "*Limnology*", McGraw-Hill Book Co., New York and London, 1935, p. 58.

[3] Birge, E. H. and Juday, C., "*A Limnological Study of the Finger Lakes of New York*", U. S. Bur. of Fish. Bull. 32, 1912, pp. 525-610.

[4] Hachey, H. B., *Monthly Weather Review*, 61 (9), 264-265 (1933).

II.

There was available a mass of temperature readings from many fresh-water bodies, chiefly streams, used for fish hatchery water supplies, and as it was important to be able to make comparisons between the temperature conditions of various hatcheries, mainly for pathological studies upon the various hatchery populations, attempts were made to use some method of comparison.

By developing the method devised by Hachey, it is believed that very satisfactory comparison can be made. Because fresh-water is covered during the winter first, by a layer of water of less density as the temperature falls below 4°C., and then by ice, radiation is so interfered with that for many weeks the temperature changes little. The sine curve indicates continuous symmetrical change, so that this departure during cold weather of observed values from a smooth or symmetrical rate of change forms an important objection to the use of such a means of comparison as a sine curve, but since one can fit such a curve quite accurately to the temperature data above 4°C., in practice it proves a very satisfactory means of comparison.

In fitting the sine equation to fresh-water data, Hachey's equation has been slightly modified, since a period (P) of fifty-two weeks, instead of one of twelve months, has been employed, and degrees rather than radians have been used in order to facilitate the use of ordinary mathematical tables by those who are not mathematicians. For the same reason, a table of sines and cosines (natural) has been worked out to half-weeks and added to this paper as an appendix. It will enable non-mathematical workers interested to use the equations.

The theory on which this application of the sine equation rests depends upon the fact that the motion of any body or point in a circular path, when plotted graphically against time, results in a characteristic curve called the sine curve, and which is expressed by the mathematical expression called the sine equation. In this case, the earth in its annual orbit around the sun in fifty-two weeks is the moving body. It is a familiar fact to all that it is this same revolution of the earth around the sun which causes the marked changes of temperature which we call the seasons.

The sine equation used here is of the form:

$$Y=A-B \sin 6.92^\circ (x-K),$$

in which Y is the temperature in degrees for any week x: A, B and K are values (constants) which must be determined for each body of water, and which are the "characteristics" of this paper. In the resulting equations, A is an average temperature (not usually, in fresh-water, the true average), B is the amplitude, and K a factor which may be called the "lag" factor, and which depends upon the point selected as the starting point.

For any body of water which does not freeze, as sea-water and certain springs, a sine curve fits the temperature data throughout the year, and A will be then the true average temperature. In fitting the sine curve to temperatures of the non-freezing period, for waters which do freeze, the theoretical values below 4°C. will depart from the actual values observed, and hence A will be lower than the true average by an amount corresponding to the duration of freezing and depending upon the amplitude.

It will be clear that, since the equation contains three unknown quantities, three separate determinations of Y (at different weeks) must be available to determine A, B and K. The most simple determinations will result by taking temperatures (Y) for the points where x corresponds to 52, 39, 26, or 13. This is because at these values of x the sine reduces to 0 or ±1.

If we place Y_0 as the temperature for $x=52$, Y_1 for $x=39$, Y_2 for $x=26$, the following relationships hold:

$$A=\frac{Y_0+Y_2}{2}$$

$$B=0.5\sqrt{(Y_0+Y_2-2Y_1)^2+(Y_0-Y_2)^2}$$

$$\sin \epsilon=\frac{Y_0-A}{B} \qquad [K=0.1\dot{4}\epsilon].$$

TABLE 1.

Temperature Equations—°C.

Hatchery	Latitude	Temperature Equation (maximum)	Temperature Equation (minimum)
Newtown, Ohio	39.1°N.	$Y = 18.7 - 13.8 \sin 6.92(x - 0.5)$	$Y = 11.3 - 14.2 \sin 6.92(x - 1.0)$
Piqua, Ohio	40.2	$Y = 17.4 - 14.4 \sin 6.92(x + 0.5)$	$Y = 10.9 - 15.5 \sin 6.92(x - 0.5)$
Xenia, Ohio	39.7	$Y = 16.7 - 12.6 \sin 6.92(x + 0.5)$	$Y = 10.8 - 13.1 \sin 6.92(x - 0.5)$
Normandale, Ontario	42.7	$Y = 13.6 - 11.6 \sin 6.92(x)$	$Y = 6.61 - 11.3 \sin 6.92(x - 1.0)$
Erwin, Tenn.	36.1	$Y = 13.1 - 0.28 \sin 6.92(x)$	
Springville, Utah	40.2	$Y = 12.3 - 0.56 \sin 6.92(x - 1.0)$	
Yarmouth, N. S.	44.0	$Y = 11.6 - 12.6 \sin 6.92(x - 1.0)$	$Y = 7.33 - 11.6 \sin 6.92(x - 1.5)$
Middleton, N. S.	44.8	$Y = 11.4 - 10.2 \sin 6.92(x)$	$Y = 6.95 - 10.2 \sin 6.92(x - 1.5)$
East Orland, Me.	44.5	$Y = 11.2 - 9.6 \sin 6.92(x - 2.5)$	$Y = 6.89 - 10.5 \sin 6.92(x - 3.0)$
Antigonish, N. S.	45.6	$Y = 10.8 - 10.8 \sin 6.92(x - 2.0)$	$Y = 4.66 - 12.7 \sin 6.92(x - 3.0)$
Ithaca, N. Y.	42.4	$Y = 10.7 - 12.7 \sin 6.92(x - 0.5)$	$Y = 6.06 - 13.8 \sin 6.92(x - 0.5)$
Bedford, N. S.	44.7	$Y = 10.2 - 13.6 \sin 6.92(x - 0.5)$	$Y = 5.89 - 12.5 \sin 6.92(x - 1.5)$
*St. Andrews, N. B.	45.1	$Y = 9.83 - 10.8 \sin 6.92(x - 1.0)$	$Y = 7.33 - 10.6 \sin 6.92(x - 1.0)$
*Birch Cove, N. B.	45.2	$Y = 9.44 - 9.6 \sin 6.92(x - 3.5)$	$Y = 4.44 - 11.2 \sin 6.92(x - 3.5)$
Kellys Pond, P. E. I.	46.3	$Y = 9.33 - 13.2 \sin 6.92(x - 1.0)$	$Y = 4.72 - 12.2 \sin 6.92(x - 1.5)$
*Magog, Quebec	45.6	$Y = 8.22 - 16.0 \sin 6.92(x - 1.5)$	
Dorion, Ontario	48.9	$Y = 8.06 - 2.4 \sin 6.92(x + 1.5)$	$Y = 5.56 - 2.1 \sin 6.92(x)$
*Chamcook, N. B.	45.2	$Y = 8.06 - 2.0 \sin 6.92(x - 13.0)$	
Miramichi, N. B.	46.9	$Y = 7.95 - 12.6 \sin 6.92(x - 0.5)$	$Y = 2.00 - 10.3 \sin 6.92(x - 2.0)$
Saint John, N. B.	45.3	$Y = 7.84 - 12.3 \sin 6.92(x - 1.0)$	$Y = 6.17 - 12.4 \sin 6.92(x - 2.0)$
Margaree, N. S.	46.2	$Y = 7.61 - 9.3 \sin 6.92(x - 2.0)$	$Y = 4.17 - 10.1 \sin 6.92(x - 3.0)$
Sault Ste. Marie, Ont.	46.6	$Y = 7.27 - 2.3 \sin 6.92(x - 1.0)$	$Y = 6.17 - 2.7 \sin 6.92(x - 2.0)$
Lac Manitou, Que.	45.9	$Y = 7.00 - 9.0 \sin 6.92(x - 2.0)$	$Y = 1.39 - 9.9 \sin 6.92(x - 2.0)$
Grand Falls, N. B.	47.2	$Y = 6.73 - 8.3 \sin 6.92(x - 1.0)$	$Y = 3.28 - 7.4 \sin 6.92(x - 2.5)$
Florenceville, N. B.	46.4	$Y = 6.67 - 10.3 \sin 6.92(x - 1.5)$	$Y = 2.61 - 8.7 \sin 6.92(x - 2.0)$
Lac Tremblant, Que.	46.3	$Y = 5.44 - 12.4 \sin 6.92(x - 1.5)$	$Y = 3.77 - 12.0 \sin 6.92(x - 1.5)$
Tadoussac, Que.	48.2	$Y = 4.66 - 14.8 \sin 6.92(x - 2.0)$	$Y = 2.84 - 14.5 \sin 6.92(x - 2.0)$
St. Félicien, Que.	48.7	$Y = 4.40 - 18.7 \sin 6.92(x - 1.5)$	$Y = 1.39 - 15.4 \sin 6.92(x - 1.5)$
Restigouche, N. B.	48.0	$Y = 4.06 - 5.8 \sin 6.92(x - 3.0)$	$Y = 2.44 - 6.2 \sin 6.92(x - 3.0)$

*In these cases, temperature readings have been available for only a single year.

TABLE 2.

Temperature Equations—°F.

Hatchery	Latitude	Temperature Equation (maximum)	Temperature Equation (minimum)
Newtown, Ohio	39.1°N.	$Y = 65.7 - 24.9 \sin 6.92(x - 0.5)$	$Y = 52.4 - 25.5 \sin 6.92(x - 1.0)$
Piqua, Ohio	40.2	$Y = 63.3 - 25.9 \sin 6.92(x + 0.5)$	$Y = 51.6 - 27.9 \sin 6.92(x - 0.5)$
Xenia, Ohio	39.7	$Y = 62.0 - 22.6 \sin 6.92(x + 0.5)$	$Y = 51.4 - 23.6 \sin 6.92(x - 0.5)$
Normandale, Ontario	42.7	$Y = 56.5 - 20.9 \sin 6.92(x)$	$Y = 43.9 - 20.4 \sin 6.92(x - 1.0)$
Erwin, Tenn.	36.1	$Y = 54.5 - 0.5 \sin 6.92(x)$	
Springville, Utah	40.2	$Y = 54.2 - 1.0 \sin 6.92(x - 1.0)$	
Yarmouth, N. S.	44.0	$Y = 52.9 - 23.1 \sin 6.92(x - 1.0)$	$Y = 45.2 - 21.2 \sin 6.92(x - 1.5)$
Middleton, N. S.	44.8	$Y = 52.6 - 18.4 \sin 6.92(x)$	$Y = 44.5 - 18.4 \sin 6.92(x - 1.5)$
East Orland, Me.	44.5	$Y = 52.1 - 17.3 \sin 6.92(x - 2.5)$	$Y = 44.4 - 18.9 \sin 6.92(x - 3.0)$
Antigonish, N. S.	45.6	$Y = 51.5 - 19.5 \sin 6.92(x - 2.0)$	$Y = 40.4 - 22.8 \sin 6.92(x - 3.0)$
Ithaca, N. Y.	42.4	$Y = 51.3 - 22.9 \sin 6.92(x - 0.5)$	$Y = 42.9 - 24.9 \sin 6.92(x - 0.5)$
Bedford, N. S.	44.7	$Y = 50.3 - 24.4 \sin 6.92(x - 0.5)$	$Y = 42.6 - 22.4 \sin 6.92(x - 1.5)$
St. Andrews, N. B.	45.1	$Y = 49.7 - 19.5 \sin 6.92(x - 1.0)$	$Y = 45.2 - 20.9 \sin 6.92(x - 1.0)$
Birch Cove, N. B.	45.2	$Y = 49.0 - 17.3 \sin 6.92(x - 3.5)$	$Y = 40.0 - 20.1 \sin 6.92(x - 3.5)$
Kellys Pond, P. E. I.	46.3	$Y = 48.8 - 23.7 \sin 6.92(x - 1.0)$	$Y = 40.5 - 21.9 \sin 6.92(x - 1.5)$
Magog, Que.	45.6	$Y = 46.8 - 28.9 \sin 6.92(x - 1.5)$	
Dorion, Ontario	48.9	$Y = 46.5 - 4.3 \sin 6.92(x + 1.5)$	$Y = 42.0 - 3.6 \sin 6.92(x)$
Chamcook, N. B.	45.2	$Y = 46.5 - 3.5 \sin 6.92(x - 13.0)$	
Miramichi, N. B.	46.9	$Y = 46.3 - 22.7 \sin 6.92(x - 0.5)$	$Y = 35.6 - 18.5 \sin 6.92(x - 2.0)$
Saint John, N. B.	45.3	$Y = 46.1 - 22.2 \sin 6.92(x - 1.0)$	$Y = 43.1 - 22.4 \sin 6.92(x - 2.0)$
Margaree, N. S.	46.2	$Y = 45.7 - 16.7 \sin 6.92(x - 2.0)$	$Y = 39.5 - 18.1 \sin 6.92(x - 2.0)$
Sault Ste. Marie, Ont.	46.6	$Y = 44.9 - 4.1 \sin 6.92(x - 1.0)$	$Y = 43.1 - 4.9 \sin 6.92(x - 2.0)$
Lac Manitou, Que.	45.9	$Y = 44.6 - 16.2 \sin 6.92(x - 2.0)$	$Y = 34.5 - 17.8 \sin 6.92(x - 2.0)$
Grand Falls, N. B.	47.2	$Y = 44.1 - 15.0 \sin 6.92(x - 1.0)$	$Y = 37.9 - 13.3 \sin 6.92(x - 2.5)$
Florenceville, N. B.	46.4	$Y = 44.0 - 18.6 \sin 6.92(x - 1.5)$	$Y = 36.7 - 15.7 \sin 6.92(x - 2.0)$
Lac Tremblant, Que.	46.3	$Y = 41.8 - 22.4 \sin 6.92(x - 1.5)$	$Y = 38.8 - 21.7 \sin 6.92(x - 1.5)$
Tadoussac, Que.	48.2	$Y = 40.4 - 26.7 \sin 6.92(x - 2.0)$	$Y = 37.1 - 26.0 \sin 6.92(x - 2.0)$
St. Félicien, Que.	48.7	$Y = 40.1 - 33.7 \sin 6.92(x - 1.5)$	$Y = 34.5 - 27.8 \sin 6.92(x - 1.5)$
Restigouche, N. B.	48.0	$Y = 39.3 - 10.5 \sin 6.92(x - 3.0)$	$Y = 36.4 - 11.1 \sin 6.92(x - 3.0)$

By means of these relationships, equations were determined for the various waters for which adequate temperature readings were available. These equations will be referred to as temperature equations to distinguish them from other equations discussed. In most cases there were maximum and minimum readings for every day, and a period of five years was used. These temperature equations appear in Table 1 in degrees Centigrade, and in Table 2 in degrees Fahrenheit. The readings were in most cases taken in the Fahrenheit scale, by means of the Six's type of maximum and minimum thermometer.

The temperature data were tabulated by weeks, and the maximum and minimum temperatures for corresponding or equivalent weeks of the five-year period were averaged. These weekly averages were then plotted graphically, and the best-fitting sine curve ascertained.

III.

The order of arrangement of the various bodies of water in the tables has been in the descending order of the constant A of the maximum temperature equations. Consideration of this order will show that there is a definite relation between the magnitude of this constant and the latitude of the bodies of water. By plotting the values of the constant A (maximum) against the latitude, a curve is obtained which can be expressed by the parabolic equation, $A = -0.0192\, z^2 + 48.5$, in which A is the constant of the temperature equation, and z is degrees of north latitude. Apparently the cosine equation, $A = 1368. \cos z - 87.2$, will fit the available data equally well, so that more data are needed to determine which of these equations best expresses the true relationship. In similar manner, the constants A of the minimum equations are related to latitude. The corresponding parabolic equation for the constant A (minimum) is $A = -0.0143\, z^2 + 34.3$, and the cosine equation is $A = 101.9 \cos z - 66.6$. While this relationship holds for the region under investigation, namely, the north and eastern part of North America, between latitudes 35°N. and 50°N., and, with one exception, between 60°W and 85°W longitude, it will not necessarily hold without modification for other regions, such, for example, as the corresponding western portion of Europe, or for regions higher in altitude, or further from the ocean, and so forth. It is of interest that a similar relationship may be derived for the average annual atmospheric isotherms and the latitude where these isotherms intersect the eastern coast of North America from Florida northwards, and that the constants are of almost the same magnitude as those for the minimum temperature-latitude relationship.

This information has a peculiar value in that by means of it one can determine readily what ought to be suitable waters, with regard to temperature, anywhere in this region for various purposes. For successful rearing of the eastern brook or speckled trout (*Salvelinus fontinalis*), the maximum temperature ought not to exceed 75°F. (24°C.), or be less than 57°F. (14°C.), an intermediate value being probably better, namely 64°F. or 18°C. (Embody[5], M'Gonigle[6]). By means of the latitude equation above, the average temperature (constant A) for a given latitude can be ascertained very nearly. Then having the average temperature, waters with a definite amplitude (constant B) must be sought for the particular purpose desired. For example, what ought to be the characteristics for the maximum temperatures for suitable brook trout waters in latitude 44°N.? We can say that the average (constant A) will be close to 52°F. (11°C.). Therefore the amplitude ought not to be greater than 23 Fahrenheit degrees or 13 Centigrade degrees, and the better values would be 12 Fahrenheit degrees or 7 Centigrade degrees. Warmer waters seem to be associated with more numerous, and more severe outbreaks of various bacterial and parasitic diseases, as well as with better growth rates, hence, for the control of disease, more temperate conditions are better, though not so good from the point of view of rapid growth. This gives for our maximum temperature equation for latitude 44°N., $Y = 11 - 7 \sin 6.92 (x - 2)$, in degrees Centigrade. The value of K will not affect the result; it merely indicates the time of year that result will occur. In the case of all the temperature equations and results in this article, the starting point selected is the last week of October, which is week 1.

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[5] Embody, G. C., *Fish Culture*, 2 (1), 1-5 (1936).
[6] M'Gonigle, R. H., *Trans. Amer. Fish. Soc.*, 62, 119-125 (1932).

Decided advantages result from having temperature readings reduced to the form of a simple well-known mathematical equation. It will be apparent that no two bodies of water, of all those analysed and tabulated in tables 1 and 2, are exactly alike. Thus the constants in these equations serve as a means of making easy comparisons between bodies of water. Since the first of these constants (A) depends on the latitude of the body of water, it must be apparent that the second (B) depends upon local characteristics, such as the shape of the basin, depth of the water stratum being measured, either in a lake, or in the earth (springs), and so on. As previously indicated, K depends upon the point of reference, the starting point, and larger or smaller K's depend on the position of the maximum (or minimum) temperature, with relation to this starting point.

By means of these equations, one can ascertain accurately the average amount of heat gained or lost, in calories per unit volume of water, between any particular times one may desire, subject only to the condition that the period is that when the surface of the water is unblanketed. This may be done by integration. It will provide the heat budget for the stratum being studied (Welch[2]) which is used by limnologists. By simple algebra, one may determine for how long the temperature will be above any selected value, on the average. One can readily find out how fast the water is heating or cooling at any given time by means of differentiation.

Another interesting possibility of this method is to use it for the prediction of temperatures which have not and perhaps cannot be measured. In the case of a spring at Chamcook, N. B., (see Tables 1 or 2), there was available only a series of summer temperatures. These had been taken by Dr. M. W. Smith, of the Atlantic Biological Station, in the summer of 1930. He obtained the following.

June	13	7.2°C.	July	7	7.7°C.	Aug.	18	8.9°C.	Sept.	29	9.9°C.
	16	7.2		14	8.0		25	9.2	Oct.	6	9.9
	18	7.2		21	8.2	Sept.	1	9.5		13	10.1
	20	7.4	Aug.	1	8.5		8	9.5	Nov.	1	9.7
	23	7.2		4	8.8		15	9.6		12	9.3
	30	7.8		11	8.7						

From the above values, a temperature equation was calculated, which, when checked against the observed values of Dr. Smith's by graphical means, proved to fit very well indeed. Since there were no temperature readings for this spring between November 12 and June 13, the equation could be further checked by taking readings in this interval. and comparing them with those predicted by the equation. Accordingly, the following readings were made:

Readings.	Observed.	Theoretical, of Calculated.
December 26, 1935	8.8°C.	8.8°C.
February 11, 1936	7.6	7.1
March 12, 1936	6.9	6.6
April 1, 1936	6.3	6.2
April 15, 1936	6.1	6.1
May 1, 1936	5.9	6.1
May 18, 1936	6.1	6.3
March 15, 1937	6.4	6.4

It can be easily seen that the agreement between the theoretical temperature calculated from the equation determined from Dr. Smith's data and that actually observed later is quite good.

It seems to be necessary to exercise caution in attempting to determine temperature equations for bodies of water for which adequate data are not available. The effects of normal fluctuations of weather need to be smoothed out by means of averages in order to have as smooth a curve of observational data as possible. In this study, five-year averages have been employed. Perhaps less than five years would provide sufficiently smoothed curves. Considerable variation resulted in temperature equations calculated for a body of water, by using values of one year only at a time, this resulting in five equations, one for each year.

Whether or not such annual differences as observed in such calculations may be significant of actual differences in the energy received in the different years, it is not possible to do more at the moment than speculate. Abbott[7] and Clayton[8] have shown that solar radiation varies in longer and shorter periods, and that there is a change of 1.4°C. in terrestrial temperatures for a change of one per cent in the solar radiation[9].

The author takes this opportunity to thank all those who have contributed or helped in any way in the preparation of this article, especially his colleague, Mr. H. B. Hachey. His thanks and appreciation are also due to the following who most kindly provided temperature data from their files: Dr. H. S. Davis, Dr. G. C. Embody, Dr. T. H. Langlois, Mr. H. H. McKay, Mr. J. A. Rodd, Mr. B. W. Taylor.

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[7] Abbott, C. G., *Sci. Monthly*, 43, 108-121 (1936).

[8] Clayton, H. H., *Monthly Weather Review*, 64, (11), 350-376 (1936).

[9] See also Shelford, V. E., "*Laboratory and Field Ecology*", Williams and Wilkins, Baltimore, 1929 and Kincer, J. B., *Monthly Weather Review*, 61 (9), 251-259 (1933).

APPENDIX.

Table of Sines and Cosines for Each Week and Half-Week, (When P = 52).

Week No.	Sine	Cosine	Week No.	Sine	Cosine
0.0 (52.0)	0.00000	1.00000	26.0	0.00000	–1.00000
0.5 (52.5)	0.06047	0.99817	26.5	–0.06047	–0.99817
1.0 (53.0)	0.12043	0.99272	27.0	–0.12043	–0.99272
1.5 (53.5)	0.18023	0.98362	27.5	–0.18023	–0.98362
2.0 (54.0)	0.23938	0.97093	28.0	–0.23938	–0.97093
2.5 (54.5)	0.29737	0.95476	28.5	–0.29737	–0.95476
3.0 (55.0)	0.35456	0.93503	29.0	–0.35456	–0.93503
3.5 (55.5)	0.41045	0.91188	29.5	–0.41045	–0.91188
4.0 (56.0)	0.46484	0.88539	30.0	–0.46484	–0.88539
4.5 (56.5)	0.51728	0.85582	30.5	–0.51728	–0.85582
5.0 (57.0)	0.56808	0.82297	31.0	–0.56808	–0.82297
5.5 (57.5)	0.61681	0.78711	31.5	–0.61681	–0.78711
6.0 (58.0)	0.66306	0.74857	32.0	–0.66306	–0.74857
6.5 (58.5)	0.70711	0.70711	32.5	–0.70711	–0.70711
7.0 (59.0)	0.74857	0.66306	33.0	–0.74857	–0.66306
7.5 (59.5)	0.78711	0.61681	33.5	–0.78711	–0.61681
8.0 (60.0)	0.82297	0.56808	34.0	–0.82297	–0.56808
8.5 (60.5)	0.85582	0.51728	34.5	–0.85582	–0.51728
9.0 (61.0)	0.88539	0.46484	35.0	–0.88539	–0.46484
9.5 (61.5)	0.91188	0.41045	35.5	–0.91188	–0.41045
10.0 (62.0)	0.93503	0.35456	36.0	–0.93503	–0.35456
10.5 (62.5)	0.95476	0.29737	36.5	–0.95476	–0.29737
11.0 (63.0)	0.97093	0.23938	37.0	–0.97093	–0.23938
11.5	0.98362	0.18023	37.5	–0.98362	–0.18023
12.0	0.99272	0.12043	38.0	–0.99272	–0.12043
12.5	0.99817	0.06047	38.5	–0.99817	–0.06047
13.0	1.00000	0.00000	39.0	–1.00000	0.00000
13.5	0.99817	–0.06047	39.5	–0.99817	0.06047
14.0	0.99272	–0.12043	40.0	–0.99272	0.12043
14.5	0.98362	–0.18023	40.5	–0.98362	0.18023
15.0	0.97093	–0.23938	41.0	–0.97093	0.23938
15.5	0.95476	–0.29737	41.5	–0.95476	0.29737
16.0	0.93503	–0.35456	42.0	–0.93503	0.35456
16.5	0.91188	–0.41045	42.5	–0.91188	0.41045
17.0	0.88539	–0.46484	43.0	–0.88539	0.46484
17.5	0.85582	–0.51728	43.5	–0.85582	0.51728
18.0	0.82297	–0.56808	44.0	–0.82297	0.56808
18.5	0.78711	–0.61681	44.5	–0.78711	0.61681
19.0	0.74857	–0.66306	45.0	–0.74857	0.66306
19.5	0.70711	–0.70711	45.5	–0.70711	0.70711
20.0	0.66306	–0.74857	46.0	–0.66306	0.74857
20.5	0.61681	–0.78711	46.5	–0.61681	0.78711
21.0	0.56808	–0.82297	47.0 (–5.0)	–0.56808	0.82297
21.5	0.51728	–0.85582	47.5 (–4.5)	–0.51728	0.85582
22.0	0.46484	–0.88539	48.0 (–4.0)	–0.46484	0.88539
22.5	0.41045	–0.91188	48.5 (–3.5)	–0.41045	0.91188
23.0	0.35456	–0.93503	49.0 (–3.0)	–0.35456	0.93503
23.5	0.29737	–0.95476	49.5 (–2.5)	–0.29737	0.95476
24.0	0.23938	–0.97093	50.0 (–2.0)	–0.23938	0.97093
24.5	0.18023	–0.98362	50.5 (–1.5)	–0.18023	0.98362
25.0	0.12043	–0.99272	51.0 (–1.0)	–0.12043	0.99272
25.5	0.06047	–0.99817	51.5 (–0.5)	–0.06047	0.99817
26.0	0.00000	–1.00000	52.0 (0.0)	–0.00000	1.00000

PRESIDENTIAL ADDRESS.

G. H. HENDERSON.

(Read October 13, 1937).

In reviewing the events of the past year I have to refer with sorrow to the deaths during that period of no less than four of our members.

Mr. Justice Humphrey Mellish was elected to this Institute in 1932. A man of wide reading and scholarship, he was keenly interested in Nature and wild life. His kindly human qualities and gifts of wit and humour combined with his legal ability to make him one of the outstanding personalities of this Province.

In the death of Mr. Hector McInnes, K.C., we have to mourn the loss of one of our oldest members, for he had been a faithful member of the Institute since 1889. A man of wide interests, his continued support of our work was typical of the manifold services he rendered to a community which recognized him as one of its leading citizens. It is not out of place here to record his long association with Dalhousie University, of whose Board of Governors he was Chairman.

Dr. E. E. Prince had been a Corresponding Member since 1897. A native of England, he was for long Commissioner of Fisheries and Chairman of the Biological Board of Canada. He was widely known as an authority on the fishes of Canada and contributed several papers to our Proceedings.

Dr. D. F. Fraser-Harris was actively associated with the Institute from the time of his arrival from Scotland in 1912 to take the Chair of Physiology at Dalhousie until he was forced to retire through illness in 1923, when he became a Corresponding Member. For three years, 1915-1918, he ably filled the office of President. Although overloaded with teaching duties which are today shared by a considerable staff, he found time to do much important research, some of the results of which were published in our Proceedings. He was not only very successful as an expositor in his specialized field but showed talents of high order in lecturing and writing on the broader aspects of Science for the general public. Dr. Fraser-Harris was also outstanding in his knowledge and appreciation of literature and history, as is evidenced by several books and many essays written both before and after his retirement from active scientific work. Rich in mind and heart, with high ideals of scholarship and character, he gave of himself unsparingly. He will long be remembered as one of the most distinguished members in the long history of the Institute.

The Institute will also miss the presence of two of its members who have left the city. One is the Rev. Brother Cornelia of St. Mary's College, a former member of Council, who has been transferred to New York. The other is Dr. Margaret Butler, who had the honour of being the first lady member of Council and who has now become Mrs. Daniel Morrison of Antigonish. Both of these members have been loyal and earnest supporters of the Institute and their absence will be regretted by all.

In the past year 6 Ordinary Members, 3 Associate Members and 5 Student Members were elected. Seven meetings of the Institute were held during the year at which 16 papers were presented. These may be classified as follows: Zoology and Fisheries, six; Chemistry, Biochemistry and Botany, two each; and Physics, Geology, Hydrology and Meteorology, one each. In December last Volume XIX, Part 2 of our Proceedings was published, containing 3 papers, 16 abstracts making a total of 56 pages.

The year just concluded was a notable one in that it was the 75th in the history of the Institute. The occasion was marked by a special meeting held in the School for the Blind on February 15th at which over 250 persons were present. After brief remarks on the history and purposes of the Institute by the President the address of the evening was delivered by Major-General A. G. L. McNaughton, C.M.G., D.S.O., President of the National Research Council of Canada, on "The Organization of Research in Canada." At the conclusion of his address the thanks of the meeting were extended to him by the President and the meeting closed with the singing of the National Anthem.

Through this meeting and through a number of articles dealing with the Institute appearing in the Press, the activities of the Institute came prominently and favourably to the attention of the public. We are greatly indebted to General McNaughton for coming from Ottawa to give us his address. This will be printed in the forthcoming number of our Proceedings.

The Institute has members throughout the Maritime Provinces and Newfoundland and papers have been received frequently from Members residing outside the city of Halifax. In order to encourage further papers from outside sources and to facilitate attendance of their authors at our meetings, the Council has this year, as an experiment, made the innovation of offering to pay part of the travelling expenses of members coming from outside to present papers. Under this arrangement Dr. H. B. Hachey of the Atlantic Biological Station, St. Andrews, N. B., gave at the regular meeting on March 15th a paper on "Ekman's Theory Applied to Water Replacements on the Scotian Shelf". The very general interest which this excellent paper aroused encourages the hope that the scheme may prove to be successful in widening the scope of the Institute.

Through the goodwill of Dalhousie University a room has been provided on the top floor of the Science Building for the storage of the stock of back numbers of our Proceedings. Adequate shelving has been provided and we now have this valuable asset stored in a fireproof building under lock and key.

In June of this year the Mining Society of Nova Scotia celebrated its 50th Anniversary. The original members of the Society having been largely drawn from among our Members, it may well be considered the child of the Institute. At the celebrations, the Institute was represented by our First Vice-President, Dr. King, who extended our congratulations and good wishes to the Society, which had already extended similar felicitations earlier in the year at our own Anniversary.

In conclusion I wish to thank the Members most sincerely for the honour they have done me in selecting me as President. I wish to thank the Members of Council and particularly the Corresponding and Recording Secretaries, the Treasurer and the Editor for the great services they have rendered to the Institute.

PROCEEDINGS OF MEETINGS.

SESSION OF 1937-38.

(All ordinary meetings were held in the Medical Science Building, Halifax).

76th Annual Business Meeting, October 13th, 1937. The annual address of the President was read by Dr. G. H. Henderson.

The Treasurer's Report showed that the receipts for the year amounted to $1,463.82; expenditures $1,299.61; leaving a balance of $164.21. Included among the expenditures an item was estimated at $750.00 to be paid very soon for the publication of the current "Proceedings" in the press. The Reserve Fund consists of $248.62 in Dominion Savings and $500.00 in Dominion of Canada 4% bonds. The Permanent Endowment consists of (a) Telephone Bonds, 6% to 1941, then 4% to 1966, $1,000.00, (b) Two Dominion of Canada Bonds 4½%, $1,000.00, (c) Dominion of Canada, 4%, $500.00.

The Corresponding Secretary reported that during the past year 148 back numbers of the "Proceedings" had been sent out, and nine new addresses had been added to the exchange list.

The Librarian reported the total number of books and pamphlets in the Provincial Science Library was now 101,867. During the year 2146 books and pamphlets were received through the exchange list; 116 books were purchased; 60 volumes were bound; and 1030 books and pamphlets were borrowed.

The Editor reported that the current number of the "Proceedings" was in press.

Officers elected for 1937-38 were as follows:

President	Dr. G. H. Henderson.
1st Vice-President	Dr. H. S. King.
2nd Vice-President	Professor R. J. Bean.
Treasurer	D. J. Matheson, Esq.
Corresponding Secretary	Dr. Ernest Hess.
Recording Secretary	Dr. F. R. Hayes.

Librarian........................Harry Piers, Esq.

Members of the Council.........Dr. C. C. Coffin, Dr. D. LeB. Cooper, E. W. Todd, Esq., Dr. Dixie Pelluet, Harry Piers, Esq., Dr. D. B. Finn, Dr. C. B. Weld.

Auditor........................Professor W. P. Copp.

Nominees to the Government as members of the Provincial Science Library Commission: Dr. G. H. Henderson and Dr. Ernest Hess.

1st Ordinary Meeting, Nov. 15th, 1937. New members announced (elected by Council November 1, 1937): Ordinary members; Dr. R. D. H. Heard, Wm. G. Dore, B.A., M.Sc., Dr. Rhoda Grant. Student members: Andrew Hollett, B.Sc., Clyde V. Myers, B.A., and Florence H. Armstrong.

Papers: The Influence of Hydrogen-ion Concentration on some Acid Resistant Bacteria by Dennis W. Watson. A Quantitative Study of the Changes in Fatty Constituents during Early Sea Urchin Development by F. Ronald Hayes. Haemoglobin Determination in Dogs by C. Beecher Weld.

2nd Ordinary Meeting, Dec. 6th, 1937. New members announced (elected by Council Nov. 29, 1937): Ordinary member, Dr. J. G. MacDougall. Student members: A. St. C. Grant, B.Sc., J. R. Downing, B.Sc., L. E. MacHattie, B.Sc., Jean W. McLellan, B. A.

Papers: The Decomposition of Methylene Esters and Paraldehydes at Low Pressures by J. R. Dacey; The Genesis of Pleochroic Haloes by G. H. Henderson.

3rd Ordinary Meeting, Jan. 17th, 1938. New members announced (elected by Council Jan. 3, 1938): Student members; J. R. Dacey, B.Sc., R. E. Smith.

Papers: The Estimation of Allantoin by Catherine F. Conway; Blood Volume in Dogs by C. Beecher Weld; A Pipette for the Micro Estimation of Respiratory Gases by F. Ronald Hayes.

4th Ordinary Meeting, Feb. 14th, 1938. New associate member announced: Albert E. Roland, M.A.

Demonstration: A Self-indicating and Recording Balance by A. L. Wood. Papers: The Origin of Russeting in the Golden Russet Apple by H. P. Bell; The Protein of the Casing of Salmon Eggs by E. Gordon Young and W. Robert Inman; A New High Vacuum Gauge by C. C. Coffin.

5th Ordinary Meeting, March 14th, 1938. New ordinary member announced (elected by Council Feb. 28, 1938): A. L. Wood, B.Sc., B. E.

Papers: Temperature Characteristics for Certain Fresh Waters by R. H. M'Gonigle; The Assay of the Oestrus-inducing Gonadotropic Principle of Human Pregnancy Urine on the Dietary Anoestrus Adult Rat by R. D. H. Heard and S. S. Weinstein; The Bird Life of the Grand Manan Archipelago by O. S. Pettingill.

6th Ordinary Meeting, April 11th, 1938. New ordinary member announced (elected by Council March 28, 1938): C. Morton Shipley, B.Sc.

Papers: Hearing Acuity Tested in the Rat by the Alimentary-motor Conditioning Method by Rhoda Grant; A New Ketone from the Urine of Pregnant Mares by R. D. H. Heard. Demonstration: Kodaline Reflex Printing by Donald Mainland.

7th Ordinary Meeting, May 9th, 1938. New ordinary member announced: Dr. Richard L. de C. H. Saunders.

Papers: The Heat Capacity of Bismuth between -80° and 120°C. by L. E. MacHattie; The Fish Population of Lake Jesse, Nova Scotia by M. W. Smith; Organic Sulphur Compounds in Coal Gas by F. B. Maddock.

F. Ronald Hayes,
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

THE INFLUENCE OF HYDROGEN-ION CONCENTRATION ON SOME ACID RESISTANT BACTERIA. Dennis W. Watson, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read Nov. 15, 1937). Fifty-three strains of bacteria resisting acid environments have been isolated and classified. Hydrogen-ion concentration tolerances have been determined under carefully controlled conditions. Proteolysis as revealed by ammonia production has been determined throughout the pH range 6.5-3.5. Micro-aerophilic species have been divided into groups according to their acidogenic, proteolytic and acid tolerant characteristics. Certain cellular reactions to hydrogen-ion concentration have been discussed.

A QUANTITATIVE STUDY OF THE CHANGES IN FATTY CONSTITUENTS DURING EARLY SEA URCHIN DEVELOPMENT. F. Ronald Hayes, Dept. of Zoology, Dalhousie Univ., Halifax, N. S. (Read Nov. 15, 1937). Periodical estimations were made of the total fat, sterol and phospholipid during the first 40 hours of development of *Arbacia,* The total fat decreases up to the time of hatching (8 hours), then increases for some 10 hours, and later decreases again. The sterol concentration remains unchanged throughout the period studied. Owing to fluctuations in the phospholipid readings, a definite conclusion could not be drawn as to whether this material is utilized as a source of embryonic energy. Of the total fat in an egg some 12.4 per-cent is sterol, and 60 per-cent phospholipid.

HAEMOGLOBIN DETERMINATIONS. C. B. Weld, Dept. of Physiology, Dalhousie Univ., Halifax, N. S. (Read Nov. 15, 1937). In the course of investigations relating to the measurement of blood volumes, a number of determinations of haemoglobin have been made. These have been done by the Van Slyke manometric oxygen capacity method, and by the Newcomer, Kny-Scheerer, and Sahli colorimetric methods upon the bloods of several dogs under varying conditions. The results of the haemoglobin determinations indicate that the ratio of the values obtained by the different methods is not always the same. The ratio differs in different dogs, and in a single dog it may change under different conditions.

THE DECOMPOSITION OF METHYLENE ESTERS AND PARALDEHYDES AT LOW PRESSURES. J. R. Dacey, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Dec. 6, 1937). By means of an optical lever manometer the decomposition velocities of methylene diacetate, ethylidene diacetate and paracetaldehyde have been determined down to initial pressures of 1/10 mm. In no case was any falling off in the rate constant observed so that the minimum number of internal degrees of freedom contributing energy to the molecular breakup is respectively 10, 12 and 15.

THE GENESIS OF PLEOCHROIC HALOES. G. H. Henderson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Dec. 6, 1937). Four new types of pleochroic haloes recently described by the writer (*Nature,* 140, 191, (1937)) are due to radioactive elements of relatively short life. In attempting to explain the origin of these haloes it is suggested that they were formed before the close of hydrothermal activity in the rocks in which they appear. It is supposed that the "parent elements" of the haloes, in radioactive equilibrium with longer lived predecessor elements, were found in hydrothermal solutions diffusing through channels or narrow clefts in the already formed biotite. At certain points in the channel where conditions were favourable for their precipitation, the parent elements were deposited and the formation of one or another of the new types of pleochroic haloes began. As the solution flowed past the point of precipitation freshly formed atoms of the parent element would be deposited and in the course of time sufficient radioactive material would have been collected in the nucleus to form a recognizable halo. This hypothesis is supported by detailed consideration of the various types of haloes.

THE ESTIMATION OF ALLANTOIN. Catherine F. Conway, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read Jan. 17, 1938). The Fosse-Maurot method for the estimation of allantoin permits a recovery of allantoin ranging from 65-95% from solutions having approximately the same titre. An investigation showed that the conditions of the method were not standardized. It was found that the potassium allantoate standard is reliable only when used immediately after preparation. Particular care must be taken during the development of the color produced by the phenylhydrazone of glyoxylic acid in the presence of concentrated hydrochloric acid and potassium ferricyanide. The solution must be heated in a bath at 100°C for exactly two minutes and immediately plunged into an ice-salt bath at—10°C. When these conditions are maintained, the intensity of the color developed is directly proportional to the concentration of the solution, when the titre of the solution is from 10-100 mgms. per litre. Cooling below—15°C increases the intensity of the color by an amount proportional to the cooling. It has also been found that complete hydrolysis of allantoin to allantoic acid is effected by heating for fifteen minutes at 90°C in 0.1 N NaOH. The allantoinase used by Fosse is unnecessary. The author's method recovers allantoin quantitatively from pure solution having a titre ranging from 5-100 mgms. per 100 cc. of solution with an error of ± 3%. The Larson and Christman methods and the author's modification were compared on urine. The Larson and Christman were found to be unreliable and did not recover added allantoin quantitatively. The author's modification did recover added allantoin quantitatively.

BLOOD VOLUMES IN DOGS. C. B. Weld, Dept. of Physiology, Dalhousie Univ., Halifax, N. S. (Read Jan. 17. 1938). Determinations of the volume of the circulating blood has been done in dogs, using the dye method with Brilliant Vital Red. It was found to range between 7% and 13% of the body weight in twenty-seven apparently normal dogs, the figures being fairly consistent in any one dog. On the day following a "Whipple Closed Loop" operation (intestinal obstruction) before vomiting becomes prominent, dogs appear well except for being somewhat apathetic. At this time the blood volume has dropped by some 20-40% and the plasma volume by 30-50%. Normal animals deprived of water for 2 or 3 days show a reduction in both blood and plasma volume in the order of 30%. Bleeding the operated animals to the extent of removing 10-20% of their original blood volume kills them at once, whereas removal of 20-25% of the original blood volume from the dehydrated dogs is well tolerated. Normal animals, two to four hours after removal of 20-25% of their blood, show an increase in the plasma volume of some 15-20% and only a slight reduction in blood volume. It is suggested from these findings that anhydremia and dehydration are not the only causes of death in the obstruction dogs, but that some "shock"-like condition is contributing.

THE ORIGIN OF RUSSETING IN THE GOLDEN RUSSET APPLE. Hugh P. Bell, Dept. of Botany, Dalhousie Univ., Halifax, N. S. (Read Feb. 14, 1938). About the time of full bloom, many epidermal cells divide by a tangential wall. Later in June all the epidermal cells become vacuolated and some divide again by tangential walls forming a layer varying from two to four cells thick. Early in July a cambium is initiated in the innermost cells of epidermal origin. This cambium is very active and immediately gives off cells which differentiate into cork. Non-russeted portions may have either a very thick convoluted cuticle or a double layer of cuticle. The development of the periderm and the histology of the mature protective layers are illustrated by fifteen figures.

THE PROTEIN OF THE CASING OF SALMON EGGS. E. Gordon Young and W. Robert Inman, Dept, of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read Feb. 14, 1938). The protein of the egg casings of *Salmo salar* has been prepared and analyzed. It has been found to be insoluble in all ordinary solvents and slowly hydrolyzed by pepsin. The content of certain amino acids has been determined as follows:—cystine 1.84% tryptophane 1.42% tyrosine 5.12% histidine 1.26% lysine 3.51% arginine 5.79%. The ratio of histidine: lysine: arginine is as 1:3:4. The protein has been classed as a pseudokeratin.

A NEW HIGH VACUUM GAUGE. C. C. Coffin, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Feb. 14, 1938). A high vacuum gauge, based on the thermal conductivity of gases at low pressures, has been developed. Pressure measurements are made by determining the rate of escape of carbon dioxide from a vessel filled with "dry ice" and immersed in the gas. The construction, calibration, advantages and disadvantages of the gauge are discussed.

THE ASSAY OF THE OESTRUS-INDUCING GONADOTROPIC PRINCIPLE OF HUMAN PREGNANCY URINE ON THE DIETARY ANOESTRUS ADULT RAT. R. D. H. Heard and S. S. Weinstein, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read March 14, 1938). The chief disadvantages of the familiar infantile rat test for the oestrus-inducing gonadotropic principle are variation in sensitivity with age and degree of accuracy attained. In most laboratories the latter is seriously restricted by the limited number of available young females of the same age. A system of assay using the dietary anoestrus adult rat (vitamin B deficiency) has been evolved which largely overcomes these objections and provides several additional advantages. The results of more than 1500 individual determinations clearly establish the suitability of the test object. The well known procedure of considering the percentage response of an adequate number (20) of animals at varying dose levels has been followed. Subdivision of the dose is unnecessary; vaginal cornification persists for 24 hours or more following a single injection of active extract. Age, degree of avitaminosis and body weight (within comparatively wide limits) are without influence. A number of successive tests (at least nine) can be carried out on the same group without appreciable disturbance in sensitivity. Dosage-response curves have been constructed for three strains of rats and have been analyzed by statistical methods.

Hearing Acuity Tested in the Rat by the Alimentary-Motor Conditioning Method. Rhoda Grant, Dept. of Physiology, Dalhousie Univ., Halifax, N. S. (Read April 11, 1938). The use of this method in testing the hearing acuity in the rat was described and illustrated by slides of the apparatus and of graphic records of the motor responses to sound stimuli. This investigation has shown that it is possible to use rats in problems concerned with the hearing mechanism. The hearing thresholds found in a number of normal and hypophyspectomized rats for different frequencies (10,000, 5000, 1000, 100 cycles) were given and briefly discussed. With the purpose of correlating possible functional changes with structural changes serial sections had been made of the middle and internal ear of the normal and hypophyspectomized rat. Slides from photomicrographs of a number of these were shown.

A New Ketone From the Urine of Pregnant Mares. R. D. H. Heard, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read April 11, 1938). Combustion figures indicate the empirical formula $C_{19}H_{26}O_3 \pm C \pm 2H$ for the new ketone. It gives a golden yellow color with the Liebermann-Burchardt reagents and a yellow to orange solution with a green fluorescence on warming with concentrated sulfuric acid. Esterifiable hydroxyl groups are absent; no product was obtained with acetic anhydride at 100°. Quantitative hydrolysis of the semicarbazone and its composition clearly establish the fact that only one oxygen atom is present in a reactive carbonyl group. The nature of combination of the remaining two oxygen atoms has not been determined.

The Heat Capacity of Bismuth Between—80° and 120° C. Lloyd E. MacHattie, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read May 9, 1938). The apparatus and methods employed have been fully described in previous papers by H. L. Bronson and co-workers (*Can. of Research*, 8, 282-303 (1933); 9, 84-93 (1933); 14, 181-199 (1936); N. S. I. S., 18, 222 (1933); 19, 211 (1936)). It was thought that the specific heat of bismuth might behave anomalously but nothing peculiar was found. In fact the linear equation, $C_p = .1238_5 + .0000445\,t$, giving the heat capacity in terms of centigrade temperature in joules per gram does not differ from the experimental curve by as much as .1% at any point. However, it is quite obvious that the slope of the experimental curve is definitely changing at both ends of the temperature range. The equation,

$$C_p = \frac{1}{209.0} D\left(\frac{119}{T}\right) + 3.99_7 \times 10^{-7}\, T^{1.703} \quad \text{in which} \quad D\left(\frac{119}{T}\right)$$

is the Debye function, 119 the characteristic temperature of bismuth, T is the absolute temperature, and the units are joules per gram, has considerable theoretical interest and fits the experimental curve so accurately that one would feel justified in considerable extrapolation.

Organic Sulphur Compounds in Coal Gas. F. B. Maddock, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read May 9, 1938). The suitabilities of sodium plumbite solution, sodium hydroxide solution, and mercuric chloride solution for removing organic sulphur compounds from coal gas have been investigated. Sodium plumbite solution and mercuric chloride solution were found to be unsuitable. By the use of sodium hydroxide solution some indications of the presence of mercaptans in Halifax coal gas were obtained. Organic sulphur compounds are removed from Halifax coal gas by scrubbing with oil. When the oil is stripped of its benzol the latter contains the sulphur compounds removed from the gas. From the results of experiments to determine the nature of the organic sulphur compounds in this benzol, it is concluded that carbon disulphide and methyl mercaptan occur in the coal gas. Very probably thiaphene is present as well. Organic sulphides are believed to be absent. In addition there is some evidence to suggest that ethyl mercaptan and the methyl thiaphenes may also be present. While methyl mercaptan has frequently been quoted as a possible constituent of coal gas, it is believed that, hitherto, no evidence to support this view has been brought forward.

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